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National Dioxin Study Tier 4
Combustion Sources: Final Test Report
Site 2, Industrial Solid Waste Incinerator ISW-A

Radian Corp., Research Triangle Park, NC

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Research Triangle Park, NC

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16. ABSTRACT

This report summarizes the results of a dioxin/furan emissions test of an industrial solid waste incinerator combusting various wastes from the manufacture of wooden windows and doors. The test was the second in a series of several dioxin/furan emissions tests conducted under Tier 4 of the National Dioxin Study. The primary objective of Tier 4 is to determine if various combustion sources are sources of dioxin and/or furan emissions. If any of the combustion sources are found to emit dioxin or furan, the secondary objective of Tier 4 is to quantify these emissions.

Industrial solid waste incinerators are one of eight combustion source categories tested in the Tier 4 program. The host solid waste incinerator, designated throughout this report as incinerator ISW-A, was selected for testing after an initial information screening and a one-day pretest survey visit.

Data presented in the report include dioxin (tetra through octa homologue + 2378 TCDD) and furan (tetra through octa homologue + 2378 TCDD) results for both stack samples and ash samples. In addition, process data collected during sampling are also presented.

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TIER 4 — COMBUSTION SOURCES

Final Test Report — Site 2
Industrial Solid Waste Incinerator ISW — A

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And

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FOREWORD

This report is the result of a cooperative effort between the Office of Research and Development's Hazardous Waste Engineering Research Laboratory (HWERL) and the Office of Air Quality Planning and Standard's Monitoring and Data Analysis Division (MDAD). The overall management of Tier 4 of the National Dioxin Study was the responsibility of MDAD. In addition, MDAD provided technical guidance for the source test covered by this report. HWERL was directly responsible for the management and technical direction of the source test.

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1.0 INTRODUCTION

This report summarizes the results of a dioxin/furan* emissions test of an industrial solid waste incinerator combusting various wastes from the manufacture of wooden windows and doors. The test was the second in a series of several dioxin/furan emissions tests conducted under Tier 4 of the National Dioxin Study. The primary objective of Tier 4 is to determine if various combustion sources are sources of dioxin and/or furan emissions. If any of the combustion sources are found to emit dioxin or furan, the secondary objective of Tier 4 is to quantify these emissions.

Industrial solid waste incinerators are among at least 16 combustion source categories being considered in the Tier 4 program. The host solid waste incinerator, designated throughout this report as incinerator ISW-A, was selected for testing after an initial information screening and a one-day pretest survey visit.

The remainder of this test report is organized as follows. A summary of test results and conclusions is provided in Section 2.0, followed by a detailed process description in Section 3.0. The source sampling and analysis plan is outlined in Section 4.0., and the dioxin test results are presented in section 5.0. Sections 6.0 through 8.0 present various testing details. These include descriptions of the sampling locations and procedures (Section 6.0), descriptions of the analytical procedures (Section 7.0), and a summary of the quality assurance/quality control results (Section 8.0). The appendices contain raw data generated during the field sampling and analytical activities.

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*The term "dioxin/furan" as used in this report refers to polychlorinated dibenzo-p-dioxin and dibenzofuran isomers with four or more chlorine atoms.

2.0 SUMMARY AND CONCLUSIONS

2.1 SOURCE SAMPLING AND ANALYSIS OVERVIEW

The host plant for the industrial solid waste incinerator test manufactures wooden windows and doors. Various wastes from the plant are burned in two controlled air incinerators. These wastes include wood scraps, plastic coated wooden window frame pieces, paint sludges, paint filters, dry paint, paper, and cardboard. Heat generated in the incinerators is recovered using waste heat boilers.

A simplified flow diagram of the incinerator and waste heat boiler tested is shown in Figure 2-1. The incinerator consists of two combustion chambers. The first or primary chamber is a starved air (30-40 percent of stoichiometric air) combustion furnace, and the secondary chamber is a refractory lined duct with oil-fired burners. Hot gases from the secondary chamber pass through the waste heat boiler prior to being exhausted through a stack. A variable ambient air intake damper located just upstream of the exhaust stack maintains a desired static pressure at the oil-fired afterburner. Batches of waste materials are fed to the furnace approximately every 10 minutes, and ash is pushed out of the furnace approximately once every 8 hours.

The gaseous, slurry, and solid sampling conducted during the incinerator ISW-A testing are summarized in Table 2-1. Dioxin/furan sampling was performed at the exhaust stack according to a modified EPA Method 5 (MM5) procedure developed by the American Society of Mechanical Engineers (ASME) for measuring emissions of chlorinated organic compounds. One modification was made to the ASME protocol for this test: the condenser preceding the XAD sorbent trap was oriented horizontally instead of vertically. Reasons for this modification are discussed in section 6.1.2. The MM5 train components and train rinses were analyzed for dioxins and furans by EMSL-RTP and ECL-Bay St. Louis, two of three EPA laboratories collectively referred to as Troika in the National Dioxin Study. The dioxin/furan analysis quantified 2,3,7,8-TCDD/TCDF* isomers and the tetra- through octa- dioxin/furan homologues present in the samples.

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*The terms TCDD and TCDF as used in this report refer to tetrachlorodibenzo-p-dioxin and tetrachlorodibenzofuran, respectively.

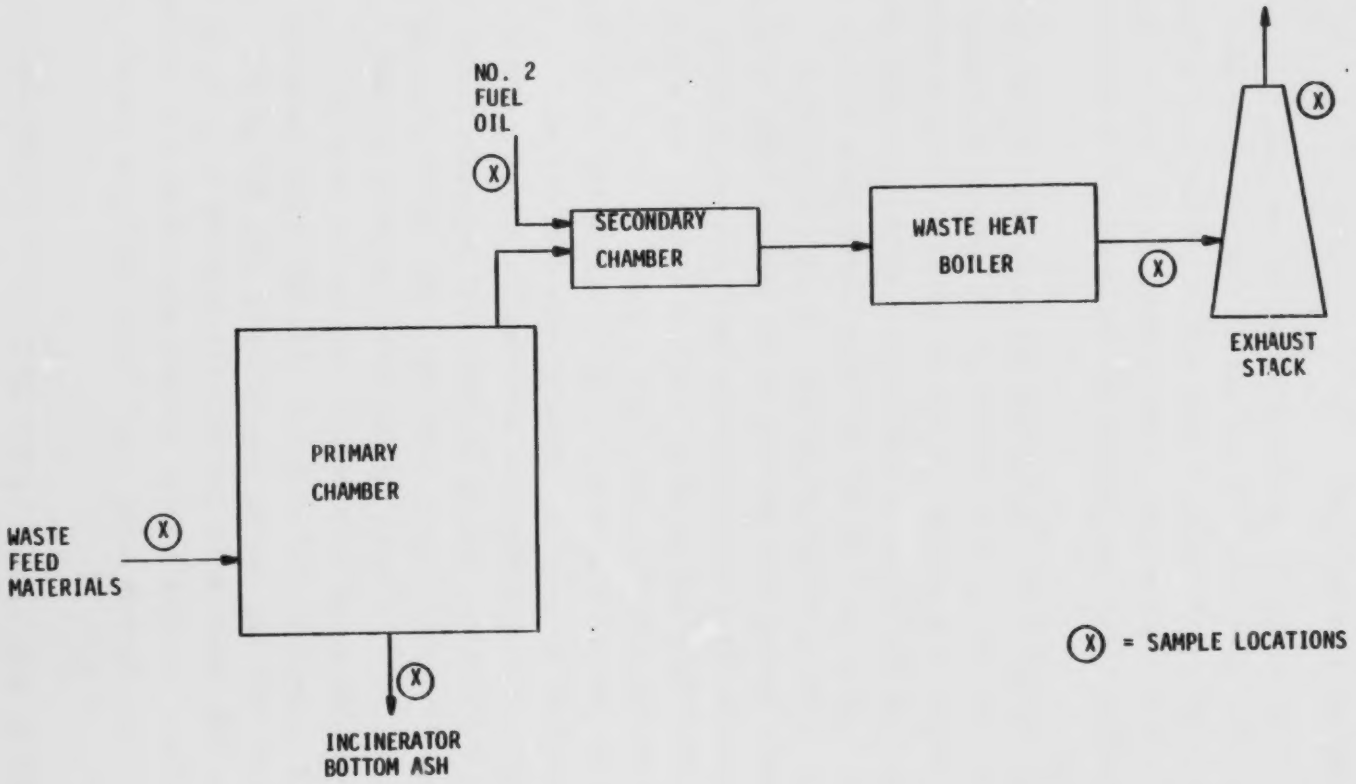

NO. 2
FUEL
OIL
X
SECONDARY CHAMBER
WASTE HEAT BOILER
X
X
EXHAUST STACK
PRIMARY CHAMBER
WASTE FEED MATERIALS
X
X
INCINERATOR BOTTOM ASH
X = SAMPLE LOCATIONS

Figure 2-1. Simplified flow diagram of incinerator and waste heat boiler at Site ISW-A

TABLE 2-1. SOURCE SAMPLING AND ANALYSIS OVERVIEW FOR SITE ISW-A

Item	Item Description
1. Number of test runs	- Four test runs (Runs 1,2,3,4)[a]
2. Gaseous sampling	- MM5 sampling at outlet exhaust stack (Runs 1,2,3,4). Dioxin/furan analysis.
	- Continuous CO, CO_2, O_2, NO_x and THC monitoring at waste heat boiler outlet (Runs 1,2,3,4).
	- Outlet exhaust stack EPA Reference Methods 2, 3, and 4 (Runs 1,2,3,4). Gas velocity, molecular weight, and moisture.
	- Ambient air sampling near the outlet stack (one composite test for Runs 1,2,3,4). Potential dioxin/furan analysis.
	- HCl sampling at outlet exhaust stack (Runs 1,2,3,4)[b].
3. Liquid Sampling	- Fuel oil sampling (Runs 1,3,4). Total chlorine analysis, dioxin/furan precursor analysis, and potential dioxin/furan analysis.
4. Solids Sampling	- Incinerator bottom ash sampling (Runs 1,3,4). Dioxin/furan analysis.
	- Weighted composite of feed samples consisting of paint sludge, wood/plastic cutoffs, wooden crate parts, paper, and cardboard (Runs 1,3,4). Dioxin/furan precursor analysis, and potential dioxin/furan analysis.
	- Soil sampling (one composite sample from ten locations). Potential dioxin/furan analysis.

a. Run 2 was aborted due to a process shutdown after completing 17 of 24 traverse points. The MM5 sample from this run was analyzed for dioxin/furan content to provide data on unsteady incinerator operation.

b. The HCl sample from Run 2 was invalidated because the glass sample probe broke during the test run.

Sampling for HCl emissions was performed at the outlet exhaust stack using another modification of EPA Method 5. Ambient air near the outlet exhaust stack was sampled using a sampling train with an XAD-2 resin trap to capture any dioxins or furans present. The purpose of this sample was to determine the level of dioxin/furan in ambient air entering an intake damper just upstream of the MM5 sample location.

Separate samples of each type of feed were collected throughout the test and weights of the materials fed during each test run were recorded. Dioxin/furan precursor analyses on the feed material samples and samples of the No. 2 fuel oil burned in the secondary chamber were performed by Radian. The precursors analyzed for included polychlorinated biphenyls (PCB), chlorobenzenes, chlorophenols, total chlorine, and total organic halide.

Continuous monitoring (CEM) was performed at the waste heat boiler outlet for CO, CO_2, O_2, NO_x and total hydrocarbons (THC). Sample of incinerator bottom ash were collected on each test day and a single set of soil samples was collected for dioxin/furan analysis.

2.2 SUMMARY OF RESULTS

Test results for Site ISW-A are summarized in Figure 2-2. The incinerator and waste heat boiler were generally operated under normal conditions during the sampling periods, although some operating problems did occur on two of the test days. Detectable quantities of all dioxin/furan species of interest were found in the stack gas samples. As shown in Figure 2-2, average stack gas concentrations of 2378 TCDD, total PCDD, and total PCDF were 0.97 ng/dscm, 129 ng/dscm, and 478 ng/dscm respectively. This corresponds to hourly mass emissions of 0.014 mg/hr 2378 TCDD, 1.81 mg/hr total PCDD, and 6.78 mg/hr total PCDF. Total dioxin and total furan emissions were evenly distributed among the tetra- through hepta-chlorinated homologues, with relatively small quantities of octa-chlorinated dioxins or furans found. There was an apparent trend in the data showing increased 2378 TCDD emission with higher HCl emissions at the stack and higher chlorine content of the feed. Similar trends were not observed for total PCDD or PCDF.

Flue Gas Parameter Data Ⓔ

Flow Rate: 238 dscmm
Temperature: 169°C
Moisture: 7.9% vol

Industrial Solid Waste Ⓐ

Crate Wood/Wood/ Paper/Cardboard	86 wt%
Wood/Plastic Cutoffs	13 wt%
Paint Sludge	1 wt%

Industrial Solid Waste Incinerator Ⓕ

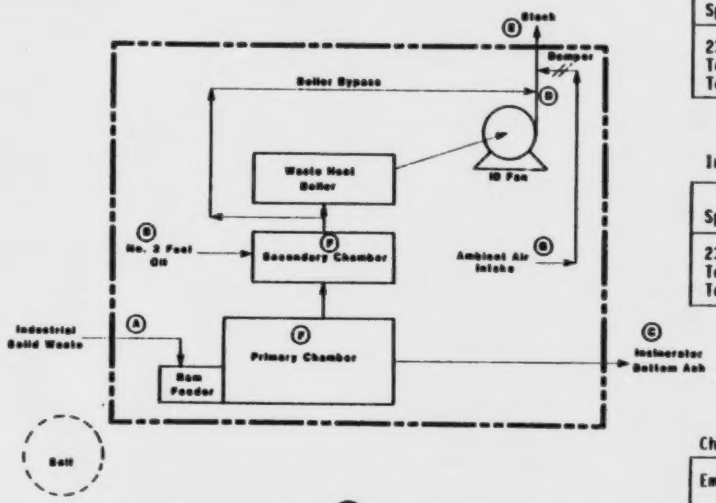
Feed Rate = 1085 kg/hr
Primary Temperature = 730°C
Secondary Temperature = 809°C

Continuous Monitoring Data Ⓓ

O_2	11.3% vol
CO_2	8.4% vol
CO	220 ppmv
THC	2.5 ppmv
NO_x	70 ppmv

No. 2 Fuel Oil Ⓑ

Flow Rate: 28 kg/hr
Chlorine Content: 20 ppm



Stack
Ⓔ
Damper
Boiler Bypass
Ⓓ
ID Fan
Waste Heat Boiler
Ⓑ
No. 2 Fuel Oil
Ⓕ
Secondary Chamber
Ambient Air Intake
Ⓖ
Industrial Solid Waste
Ⓐ
Ⓕ
Primary Chamber
Ram Feeder
Ⓒ
Incinerator Bottom Ash
Salt

Feed Precursor Data Ⓐ

Crate/Wood/Paper/Cardboard	
PCB's	not detected
Chlorobenzenes	not detected
Chlorophenols	detected
Wood/Plastic Cutoffs	
PCB's	not detected
Chlorobenzenes	not detected
Chlorophenols	detected
Paint Sludges	
PCB's	not available
Chlorobenzenes	not available
Chlorophenols	detected

Ambient Air Data Ⓖ

Species	Concentration (ng/dscm)
2378 TCDD	Not available
Total PCDD	Not available
Total PCDF	Not available

Incinerator Ash Data Ⓒ

Species	Concentration (ppb)
2378 TCDD	not available
Total PCDD	not available
Total PCDF	not available

Chloride Emissions Data Ⓔ

Emissions Type	Concentration (mg/dscm)	Emission Rate (kg/hr)
Train Total	1980	28.4
Back Half	1950	27.9
Front Half	30	0.5

Dioxin/Furan Emissions Data Ⓔ

Species	Concentration (ng/dscm)	Emission Rate (mg/hr)	Emission Factor (ug/kg)
2378 TCDD	0.97	0.014	0.013
Total PCDD	129	1.81	1.70
Total PCDF	478	6.78	6.30

Figure 2-2. Data Summary for Incinerator ISW-A

Incinerator ash, ambient air and soils samples have not yet been analyzed for dioxins and furans.

The predominant dioxin/furan precursors found in the incinerator feed were tetra and pentachlorophenols. Total chlorine analysis showed a chlorine level near 1.0 percent in a composite feed sample.

The incinerator feed rate during the testing averaged 1085 kg/hr (2390 lb/hr). Total exhaust stack chloride emissions averaged 28.4 mg/hr. Most of the chloride (>98 percent) was emitted as HCl. Continuous flue gas monitoring results for the waste heat boiler outlet were: O_2, 11.3 vol. %; CO_2, 8.4 vol %; CO, 220ppmv; THC, 2.5 ppmv; NO_x, 70 ppmv.

3.0 PROCESS DESCRIPTION

This section describes the controlled air incinerator tested at Site ISW-A as well as the sources and types of the various materials fed to the incinerator.

3.1 INCINERATOR DESCRIPTION

The Kelley Model 2500 controlled air incinerator at Site ISW-A has two combustion chambers. The first or primary chamber consists of a 19.1 m^3(675 ft^3) furnace operated under "starved air" conditions (30-40 percent of stoichiometric air). The secondary combustion chamber is a refractory lined duct with oil-fired burners. The incinerator, which was started up in September 1981 and operates 24 hours a day, 5 days a week, has a rated capacity of 5.3 MJ/s(18 MMBtu/hr) heat input. Exhaust gas from the incinerator is ducted to a waste heat boiler to make process steam for space heating or compressed air production. A schematic diagram of the system is shown in Figure 3-1.

Approximately 1 ton of waste materials, consisting primarily of wood, cardboard, and paper, are fed to the furnace each hour. The waste is charged to the furnace in 45.4 to 409 Kg (100 to 900 lb) batches every 10 minutes using a ram feeder. The furnace typically operates at 650^{o}C (1200^{o}F) and has water spray capability to prevent excursions above about 760^{o}C (1400^{o}F).

Ash is removed from the furnace approximately once every 8 hours using a ram discharging system. The average residence time of the ash in the furnace is 10 to 12 hours. Ash leaving the system is cooled by water spraying and conveyed to a hopper for eventual landfill disposal. Material in the furnace is typically allowed to burn down each weekend, and all ash is removed prior to startup on Monday mornings. The total ash produced by the incinerator is approximately 1.5 Mg (1.7 tons) per day.

The secondary chamber has two No. 2 oil-fired burners. Incomplete combustion products from the furnace are burned in the secondary chamber under excess air conditions. Combustion air is induced into the chamber by natural

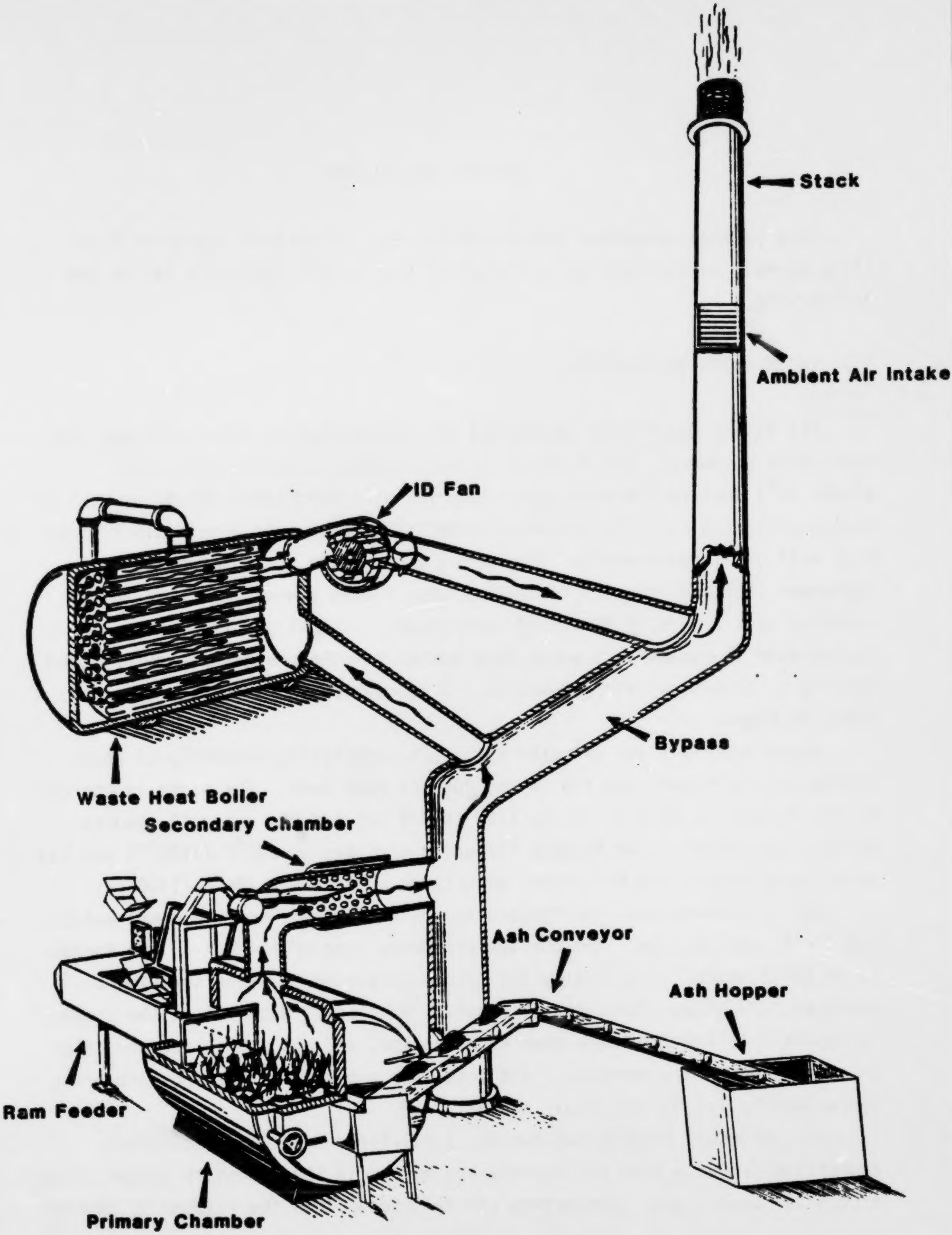

Stack
Ambient Air Intake
ID Fan
Bypass
Waste Heat Boiler
Secondary Chamber
Ash Conveyor
Ash Hopper
Ram Feeder
Primary Chamber

Figure 3-1. Schematic diagram of incinerator and waste heat boiler at Site ISW-A

draft. An ambient air intake damper located just upstream of the boiler outlet exhaust stack fluctuates to maintain a design draft of 0.18 to 0.30 inches of water in the secondary chamber. The gas residence time in the chamber, which has a set-point operating temperature of 870°C (1600°F), is at least 0.5 seconds. The ductwork from the secondary chamber to the waste heat boiler is also lined with refractory, providing an additional residence time of approximately 0.5 seconds at the secondary chamber temperature. The oil-fired burners in the secondary chamber do not have the capacity to maintain a secondary operating temperature of 870°C (1600°F) at all times. Much of the heat required for extended operation at this temperature comes from combustion of unburned or partially oxidized gases leaving the secondary chamber. Hence, during startup periods and periods when the material feedrate is low or highly variable, the set-point temperature of 1600°F is not attained. A totalizer is used to record the volume of No. 2 fuel oil fired in the burners, and temperature indicators provide a measurement of the primary and secondary chamber operating temperatures.

The induced draft (ID) fan at the outlet of the waste heat boiler is controlled to meet the steam demand of the plant. When steam demand is high, the fan typically operates continuously so that all of the gas exiting the incinerator passes through the boiler. However, when steam demand is lower, the ID fan is cycled on and off to provide only the required amount of steam. During the period that the ID fan is off, exhaust gas bypasses the boiler and leaves the stack by natural draft. The total gas volume exiting the system exhaust stack during operation with the ID fan was 6.6 m^3/s at 170°C (14,000 acfm at 335°F). Approximately 45 percent of this gas volume enters the stack at the ambient air intake damper.

3.2 WASTE FEED MATERIALS

The following waste materials are normally fed to incinerator ISW-A:

- paint filters and dry paint,
- paint sludge,
- wood/plastic cutoffs,

- scrap wood,
- wooden crate parts,
- paper and cardboard, and
- office and cafeteria waste.

The paint filters and dry paint come from electrostatic paint booths used to coat window frame parts prior to window fabrication. The paint sludge also results from the window frame painting operations. The paint sludge is burned in 5-gallon plastic buckets. Two types of sludge are burned, latex and "Hytest," at a combined rate of 15 to 20 buckets per shift. The latex is from a water-based paint and the Hytest is from an oil or aromatic compound-based paint.

The wood/plastic cutoffs are 6 to 8 in^3 pieces of polyvinyl chloride (PVC) coated window frame parts, consisting of approximately 50 percent wood and 50 percent PVC by weight. The wooden window frames are treated with 0.1 lb/ft^3 of pentachlorophenols (PCP), and the PVC is extruded over the wood. The cutoffs result from the mitering of window frame parts to form the corners of the windows. Scrap wooden window frames treated with tributyl tin oxide and/or paint are also burned in the incinerator. The wooden crate parts, paper, and cardboard are basically waste packing materials used to store or protect various materials, such as glass, purchased by the plant for the production of windows and doors.

The percent of total feed, heating value, and ash content of the various waste materials typically fed to the Site ISW-A incinerator are shown in Table 3-1. To simplify the feed material sampling effort, two of the feed types listed in Table 3-1 were not fed to the incinerator during the dioxin/furan emissions testing. Cafeteria and office wastes were not burned during the testing because of the potential diversity of the materials and the corresponding difficulty in obtaining representative samples. Paint filters and dry paint were also not fed during the test because these materials are burned only twice per day at times outside of the planned test period. The two types together constitute only 3 percent of the typical feed composition and are not expected to contain significant amounts of dioxin/furan precursor not present in the other feed materials.

TABLE 3-1. CHARACTERISTICS OF WASTE FEED MATERIALS

Waste Feed	Weight Percent of Total Feed	Heating Value (Btu/lb)[a]	Ash (%)
Wood	60%	7,281	1.7
Cardboard and Paper	25%	9,152	6.2
Plastics	10%	7,015	38.7
Office and Cafeteria Wastes	2%	7,932	7.2
Liquid Paint	2%	12,559	8.7
Paint filters and dry paint	1%	8,156	47.4

[a] To convert from Btu/lb to J/g multiply by 2.324.

4.0 TEST DESCRIPTION

This section describes the field sampling, process monitoring, and analytical activities that were performed for test Site ISW-A. The purpose of the section is to provide sufficient descriptive information about the test so that the test data presented in Section 5.0 can be easily understood. Specific testing details (specific sampling locations and procedures) will be presented later, in Sections 6.0 and 7.0.

The remainder of this section is divided into three parts. Section 4.1 summarizes field sampling activities, Section 4.2 summarizes process monitoring activities, and Section 4.3 summarizes analytical activities performed during the test program.

4.1 FIELD SAMPLING

Table 4-1 shows the source sampling and analysis matrix for test Site ISW-A. Four dioxin/furan emissions tests were performed at the system outlet stack. This location is shown as Point E on Figure 4-1. Dioxin/furan sampling followed the Modified Method 5 (MM5) sampling protocol developed by the American Society of Mechanical Engineers (ASME) for measuring emissions of chlorinated organic compounds. Three of the four emissions tests were conducted over a 240 minute sampling period. The second test run (run 2) was aborted after 170 minutes of sampling due to failure of a hydraulic oil line on the feed ram of the incinerator.

Concentrations of HCl in the flue gas were determined for each test day using another modification of EPA Method 5. The sampling train was identical to that of Method 5 except that water in the impingers was replaced with 0.1 m NaOH. The impinger and filter catch was analyzed by ion chromatography to determine chloride concentrations.

Continuous emissions monitoring (CEM) of O_2, CO, CO_2, NO_x, and total hydrocarbons (THC) was performed during the four MM5 test runs. These data were obtained to assess variations in combustion during the sampling periods.

Table 4-1. Source Sampling and Analysis Matrix - Site ISW-A

Sample Location	Sample Type or Parameter	Sampling Method	Analysis Method	Number of Samples or Frequency
System outlet exhaust stack (point E on Figure 4-1)	Dioxin, furan	Modified EPA Method 5 (MM5)	Gas chromatograph/ mass spectometeter	Four test runs[a]; one per test day.
	Volumetric flow	EPA Method 2	NA[b]	Once per MM5 test run.
	Molecular weight	EPA Method 3	Gas chromatograph/ thermal conductivity detector	Six to eight integrated bag samples per MM5 test run.
	Moisture	EPA Method 4	Gravimetric balance	Once per MM5 test run.
	HCl	HCl acid train	Ion chromatograph	Once per MM5 test run.
Boiler outlet sample location (point D on Figure 4-1)	CO/CO_2	In-stack filter probe and heat-traced Teflon^{R} line	Nondispersive infrared analyzer	Continuously during MM5 test runs.
	O_2	Same as CO/CO_2	Paramagnetic analyzer	Continuously during MM5 test runs.
	NO_x	Same as CO/CO_2	Chemiluminescent analyzer	Continuously during MM5 test runs.
	Total hydrocarbons (THC)	Same as CO/CO_2	Flame ionization analyzer[c]	Continuously during MM5 test runs.
Ambient Air	Dioxin, furan	Ambient air/XAD resin train	Gas chromatograph/mass spectrometer	One sample taken continuously during four MM5 test runs.
Incinerator feed material	Wood/wood crate parts/ paper/cardboard for dioxin, furan, and dioxin precursors	Grab samples	Gas chromatograph/mass spectrometer	Duplicate composite or integrated sample for each MM5 test run.
	Wood/PVC cutoffs for dioxin, furan, and dioxin precursors	Grab samples	Gas chromatograph/mass spectrometer	Two grab samples of sawdust and one grab sample of pieces per MM5 test run.
	Latex paint sludge for dioxin, furan, and dioxin precursors	Grab samples	Gas chromatograph/mass spectrometer	Duplicate composite samples from two buckets; once per MM5 test run.
	Hytest paint sludge for dioxin, furan, and dioxin precursors	Grab samples	Gas chromatograph/mass spectrometer	Duplicate composite samples from two buckets; once per MM5 test run.

Table 4-1. Source Sampling and Analysis Matrix - Site ISW-A (cont'd.)

Sample Location	Sample Type or Parameter	Sampling Method	Analysis Method	Number of Samples or Frequency
Ash conveyor/hopper	Bottom ash for dioxin, furan	Grab samples	Gas chromatograph/mass spectrometer	Once during MM5 test runs.
Ash handling area	Soils for dioxin, furan	Grab samples	Gas chromatograph/mass spectrometer	One composite of 10 samples.
Oil feed line	Fuel oil for total chlorine, dioxin, furan and dioxin precursors	Tap valve sample	Gas chromatograph/mass spectrometer	Triplicate composite grab samples for each test run.

[a] The second test run was aborted after completing 17 of 24 traverse points due to failure of a hydraulic oil line on the incinerator feed ram.

[b] NA - not applicable.

[c] The flame ionization analyzer was calibrated using propane standards.

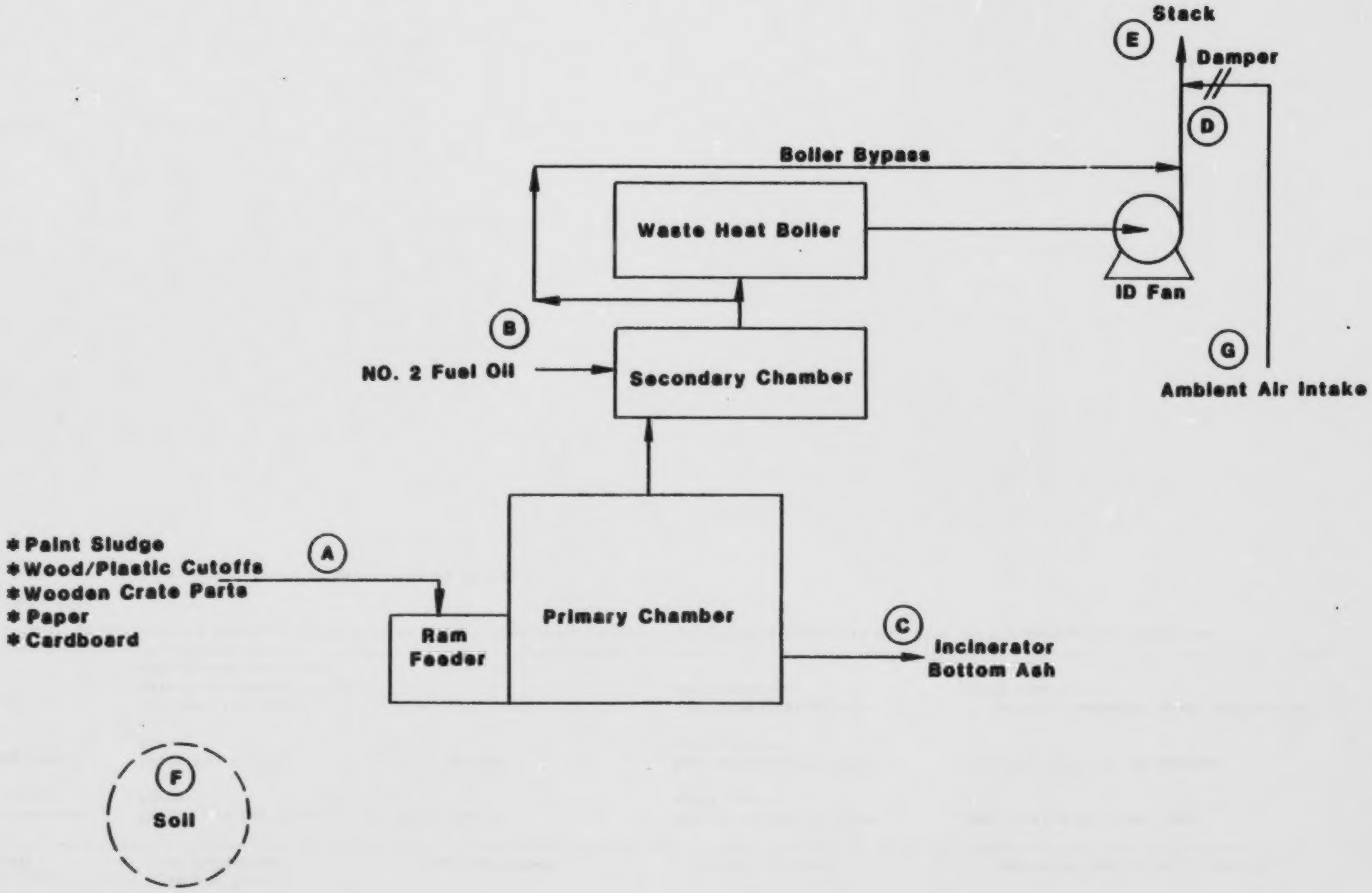

Stack
E
Damper
D
Boiler Bypass
Waste Heat Boiler
ID Fan
B
NO. 2 Fuel Oil
Secondary Chamber
G
Ambient Air Intake
*Paint Sludge
*Wood/Plastic Cutoffs
*Wooden Crate Parts
*Paper
*Cardboard
A
Ram Feeder
Primary Chamber
C
Incinerator Bottom Ash
F
Soil

Figure 4-1. Process flow diagram and sample locations for Site ISW-A

Instantaneous concentrations of each species monitored were determined and recorded every five minutes by the CEM system.

Ambient air sampling was performed at the stack ambient air intake (Point D on Figure 4-1) using an ambient XAD sampling train. A single integrated sample was collected for all four MM5 test runs. This sample was collected to determine the presence or absence of dioxin in the ambient air entering the stack through the damper during the MM5 sampling periods.

Three types of process samples were taken during the MM5 test periods: waste feed material, fuel oil, and bottom ash. The feed material and fuel oil samples were taken to characterize dioxin/furan and dioxin/furan precursor contents of the material fed to the incinerator. Bottom ash samples were taken to determine dioxin/furan is present in the ash.

Soil samples were collected from ten locations at the plant site. The ten samples were combined into a single composite, which was held for potential dioxin/furan analysis pending evaluation of the emissions data.

4.2 PROCESS DATA COLLECTION

Process data were collected on-site to characterize the operation of the incinerator and waste heat boiler during the MM5 test periods. Incinerator process data obtained include waste material feed rates, primary and secondary combustion chamber temperatures, secondary chamber draft, cooling water injection rates and oil usage. Waste heat boiler data collected include steam production rate and steam pressure. The total weight and type of feed were recorded for each batch of material fed to the incinerator. Other data were recorded manually at intermittent times throughout the test period. The process data will be used in Section 5.1 with the CEM data to evaluate and compare combustion conditions during the four MM5 test periods.

4.3 LABORATORY ANALYSES

Laboratory analyses performed on samples from test Site ISW-A included dioxin/furan analyses, dioxin/furan precursor analyses, chloride analyses, and organic halide analyses. Samples analyzed for dioxin/furan are discussed in

Section 4.3.1 and samples analyzed for dioxin precursors are discussed in Section 4.3.2. The only samples analyzed for chloride (Cl^-) were those from the HCl acid train, and this analysis was performed using ion chromatography.

4.3.1 Dioxin/Furan Analyses

All dioxin/furan analyses for Site ISW-A samples were performed by EMSL-RTP and ECL-Bay St. Louis, Missouri, laboratories, two of three EPA laboratories known as Troika. Dioxin/furan analyses were performed by gas chromatography/mass spectroscopy. Specific isomers identified included 2378 TCDD and 2378 TCDF. Other dioxin/furan compounds were quantitated in groups according to the number of chlorine atoms per molecule. The tetra- through octa-chlorinated homologues were quantified.

4.3.2 Dioxin/Furan Precursor Analyses

Dioxin/furan precursor analyses of incinerator feed materials were performed by Radian using gas chromatography/mass spectrometry. The specific dioxin/furan precursors analyzed for included chlorophenols, chlorobenzenes, and PCB's. Composite feed samples were also analyzed for total chlorine by Parr bomb combustion followed by ion chromatography and for total organic halide by gas chromatography and Hall detector.

5.0 TEST RESULTS

The results of the Tier 4 dioxin/furan emission tests of incinerator ISW-A are presented in this section. The individual test runs are designated as Runs 1 through 4. Process data obtained during all four test runs are presented in Section 5.1 and continuous monitoring data are discussed in Section 5.2. Flue gas parameter data, dioxin/furan emissions, and HCl emissions are discussed in Sections 5.3, 5.4, and 5.5 respectively. Results of analyses for ash dioxin/furan, feed dioxin/furan precursors, ambient air dioxin/furan and soil dioxin/furan are discussed in Sections 5.6 through 5.8.

5.1. PROCESS OPERATING DATA

Data summarizing operation of the incinerator and waste heat boiler during the four test runs are shown in Tables 5-1 and 5-2. These data include average waste feed rates, combustion temperatures, water injection rates, steam production and oil usage. Waste feed rates were obtained by weighing each batch of material charged to the incinerator, and all other data were obtained by manually recording values from existing temperature, pressure and flow rate indicators.

Comparison of average waste material feed rates for each of the four test runs shows a fairly wide range from 924 to 1216 kg/hr (2037 lb/hr to 2680 lb/hr) for test Runs 2 and 4, respectively. These feed rates are at or above the design feed rate of approximately 908 kg/hr (2000 lb/hr). A breakdown of the waste feed materials according to the type of waste is presented in Table 5-3. The data in Table 5-3 show similar feed compositions for all four test runs with two exceptions. Test Run 2 had a comparatively high percentage of painted wood and test Run 3 had a high percentage of wood/plastic cutoffs.

Other operating data in Table 5-1 show similar mean primary chamber temperatures for Runs 1, 3, and 4 and similar mean secondary temperatures for Runs 2, 3, and 4. The higher mean secondary chamber temperature for Run 1 resulted from comparatively steady operation of the incinerator at a relatively high feed rate. There is no apparent reason for the higher primary

TABLE 5-1. SUMMARY OF FEED RATE, TEMPERATURES AND SECONDARY CHAMBER DRAFT DURING TESTING[a]

Test Run	Sampling Time (minutes)	Average Total Feed (lb/hr)	Average Temperatures Primary (°F)	Average Temperatures Secondary (°F)	Temperature Ranges Primary (°F)	Temperature Ranges Secondary (°F)	Secondary Draft (inches H_2O)[b]
1	240	2392	1343	1629	1200-1550	1400-1750	0.35
2	170	2037	1530	1453	1400-1600	1250-1800	0.39
3	240	2087	1359	1414	1100-1800	940-1820	0.37
4	240	2680	1338	1421	1150-1700	1000-1800	0.37

[a] Data presented in this table were collected in English units. To convert from lb to kg, multiply by 0.454; inches H_2O to kPa, multiply by 0.2488; °C = (°F-32)/1.8.

[b] The setpoint range for the secondary draft was 0.18 to 0.3 inches H_2O. Operation within this range was not possible even though the air intake dampler at the stack was fully open.

TABLE 5-2. SUMMARY OF WATER INJECTION RATES, OIL USAGE, AND STEAM CONDITIONS DURING TESTING[a]

Test Run	Average Water Injection Primary (gpm)	Average Water Injection Secondary (gpm)	Incinerator Oil Usage Average (Range) (gph)	Average Steam Conditions Rate (lb/hr)	Average Steam Conditions Pressure (psig)
1	38	5	NA[b]	6600	12
2	55	4	8.9 (7.6-15.6)	5000	12
3	45	5	7.2 (0-10.9)	7430	12
4	53	6	9.7 (5.6-12.1)	7880	12

[a] Data presented in this table were collected in English units. To convert from gallons to m^3, multiply by 3.785×10^{-3}; lb to kg, multiply by 0.454; psi to kPa, multiply by 6.895.

[b] NA = not available

TABLE 5-3. BREAKDOWN OF INCINERATOR FEED MATERIALS BY TYPE

Test Run	Average Total Feed (kg/hr)	(lb/hr)	Crate, Wood, Paper Cardboard (wt. %)	Treated Wood[a] (wt. %)	Painted Wood[b] (wt. %)	Wood/ Plastic Cutoff[c] (wt. %)	Paint Sludges[d] Laytex (wt. %)	Hytest (wt. %)
1	1085	2392	68.6	5.5	15.5	9.2	0.5	0.6
2	924	2037	57.9	8.5	25.0	7.6	1.1	0
3	947	2087	62.3	6.8	12.6	17.5	0.5	0.4
4	1216	2680	71.5	NA[e]	15.4	11.3	0.9	0.9

[a] Wood treated with 1.6 kg/m^3 (0.1 lb/ft^3) of pentachlorophenols (PCP).

[b] Painted wood treated with tributyl tin oxide.

[c] Wood treated with 1.6 kg/m^3 (0.1 lb/ft^3) of PCP and coated with polyvinyl chloride (PVC).

[d] The laytex paint is water-based and the "Hytest" is oil-based.

[e] Not available. Value included with crate wood, paper and cardboard.

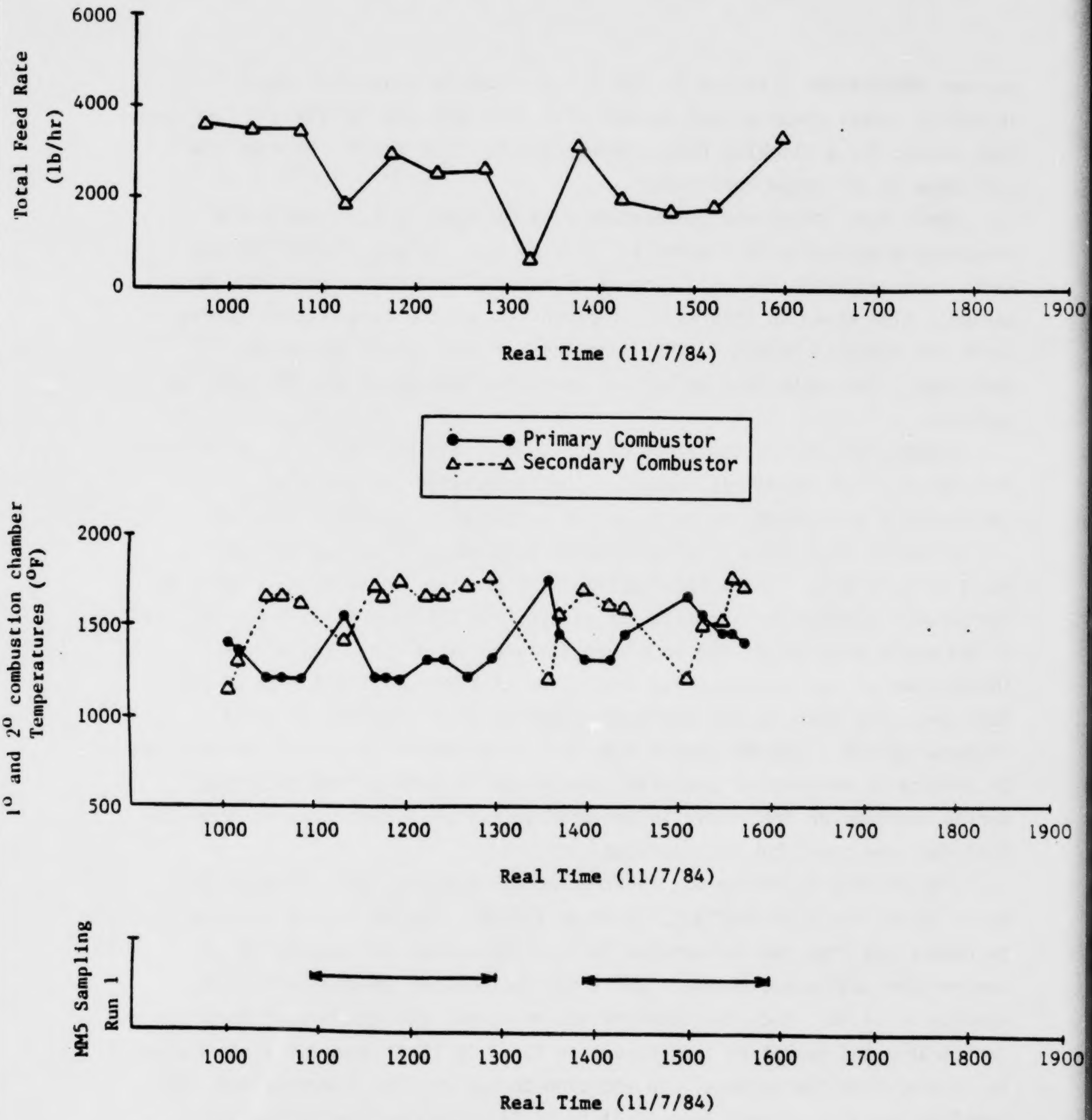
chamber temperature observed for Run 2. As shown in Table 5-2, water injection rates, steam production and oil usage were similar for all four test runs except for a slightly lower steam production for Run 2. No data are available on oil usage during Run 1.

Waste feed totals and temperature data for Runs 1, 2, 3, and 4 are presented graphically in Figures 5-1 through 5-4. Values plotted for the waste feed represent the total amount of material fed during each half hour period. Also shown in Figures 5-1 through 5-4 are the time periods during which the modified Method 5 (MM5) sampling for dioxins and furans was performed. The waste heat boiler was operating throughout the MM5 sampling periods.

Immediately before the start of Run 1, most of the ash in the incinerator from the previous shift was removed. The incinerator was operated continuously throughout the test day and no operating problems occurred.

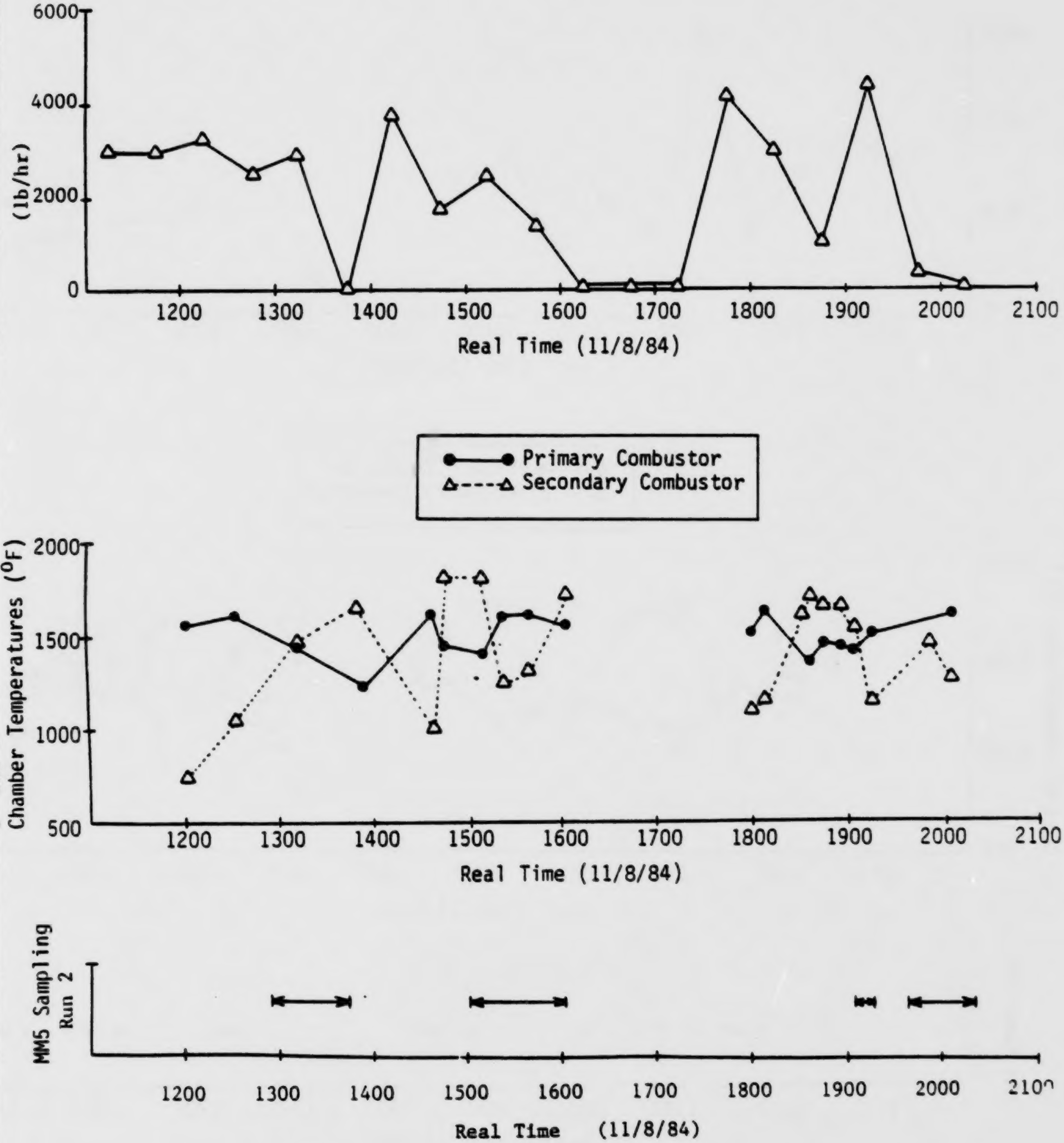
A number of process interruptions or problems were encountered during Run 2 (Figure 5-2). These interruptions and problems included 1) a delay in incinerator startup for installation of oil flow totalizers, 2) temporary loss of the waste heat boiler due to a pump failure, and 3) shutdown of the incinerator on two occasions due to failure of a hydraulic oil line on the feed ram. The test run was ultimately aborted after sampling 17 of 24 traverse points. The MM5 sample from this test run was recovered and analyzed to provide an estimate of potential dioxin and furan emissions occurring during unsteady or frequently interrupted operation. Other samples from the test run were saved but not analyzed.

Incinerator operation was interrupted twice during Run 3 (Figure 5-3). Prior to the start of the test, 11:00 on 11/9/84, the chain-link conveyor used to remove ash from the incinerator failed. Operation and testing of the incinerator continued, however, until the incinerator became too full to operate at 14:40. Once the conveyor was repaired, ash was removed from the incinerator and operation continued from 15:53 to 16:50 when ash again had to be removed from the furnace. In addition to the process interruptions, MM5 sampling was also stopped from 13:11 to 14:24 to change the particulate filter.



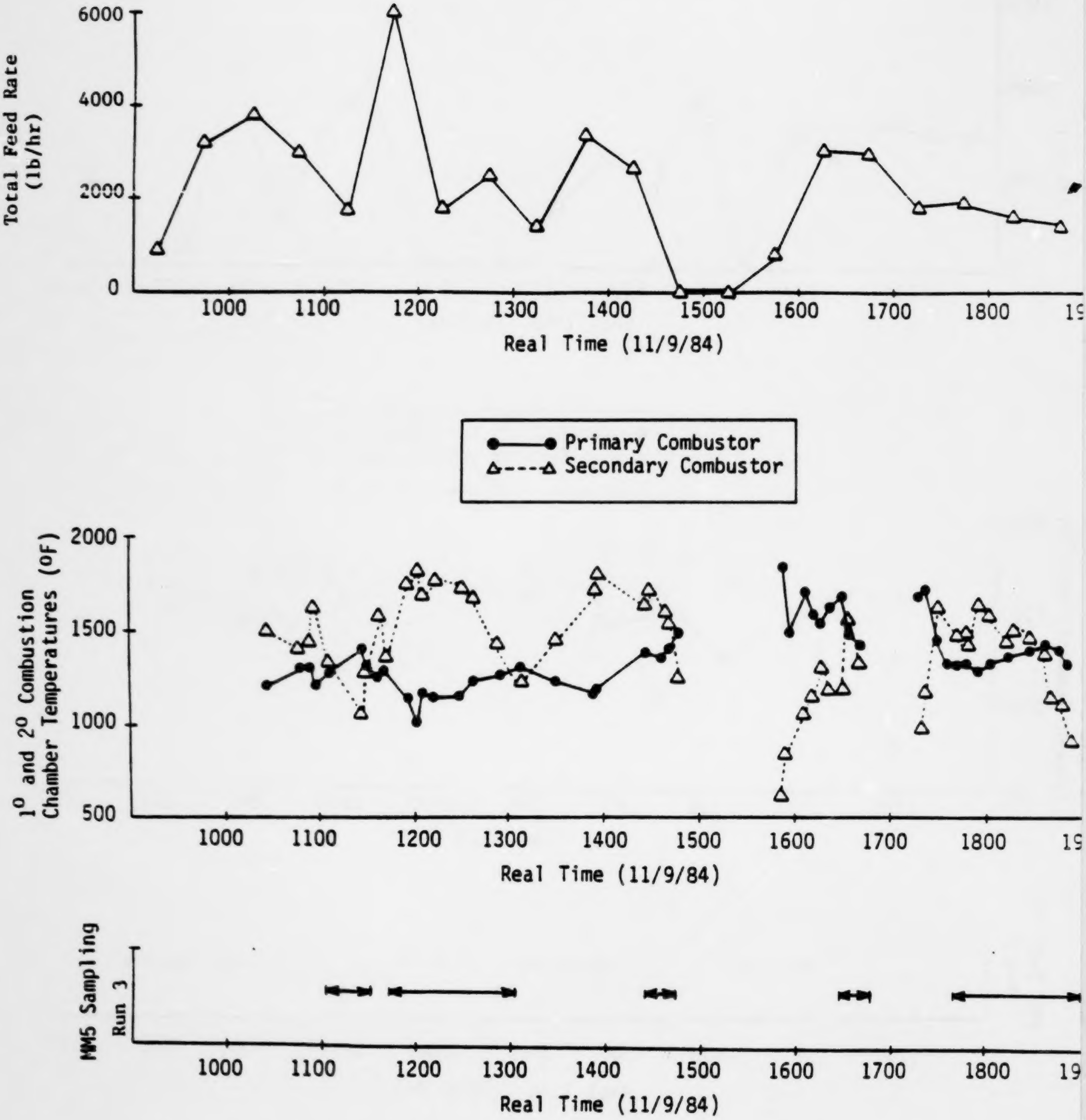
Note: To convert from lb/hr to Kg/hr multiply by 0.454; °C= (°F-32)/1.8.

Figure 5-1. Material feed rates and combustion temperatures - Run 1.



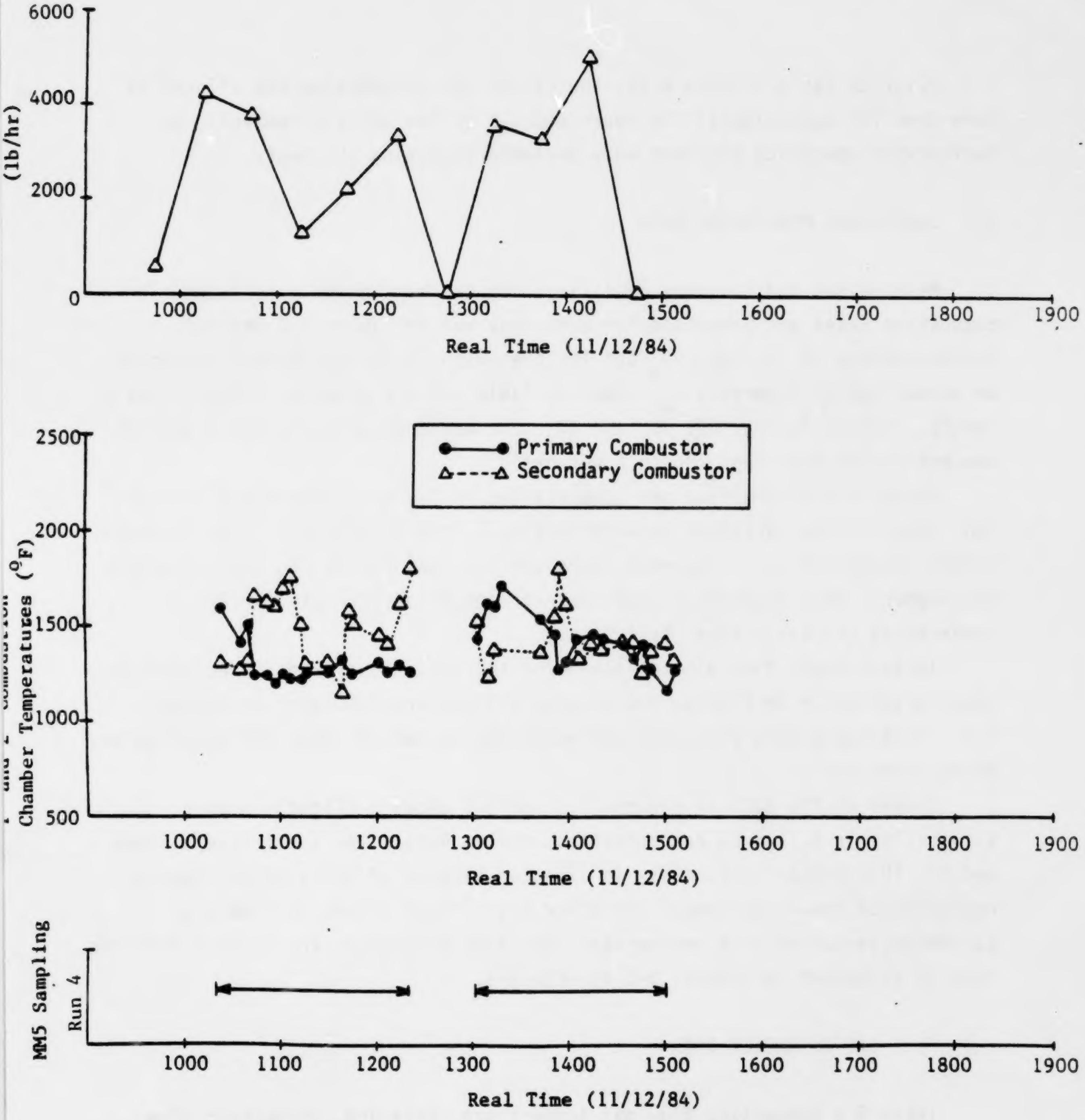
Note: To convert from lb/hr to Kg/hr multiply by 0.454; °C = (°F-32)/1.8

Figure 5-2. Material Feed Rates and Combustion Temperatures - Run 2



Note: To convert from lb/hr to Kg/hr multiply by 0.454; ⁰C = (⁰F-32)/1.8

Figure 5-3. Material Feed Rates and Combustion Temperatures - Run 3



Note: To convert from lb/hr to Kg/hr multiply by 0.454; °C = (°F-32)/1.8

Figure 5-4. Material Feed Rates and Combustion Temperatures - Run 4

Prior to Run 4 (Figure 5-4), the ash in the incinerator was allowed to burn down for approximately 24 hours and all of the ash was removed. No incinerator operating problems were encountered during the test.

5.2 CONTINUOUS MONITORING DATA

Mean values and standard deviations for the continuously monitored combustion gases are presented for each test run in Tables 5-4 and 5-5. Concentrations of CO, CO_2, NO_x and THC presented in Table 5-5 were corrected or normalized to 3 percent O_2. Data in Table 5-5 are given at actual stack O_2 levels. Values for O_2, CO, CO_2 and NO_x were measured on a dry basis and THC concentrations were measured on a wet basis.

Comparison of the flue gas compositions in Table 5-5 for the four test runs shows little variation between Runs 2, 3, and 4. For Run 1, the average oxygen concentration is somewhat lower and the mean CO and CO_2 concentrations are higher. This suggests a lower excess combustion air rate for Run 1 compared to the other three test runs.

Instantaneous five-minute values for the continuously monitored gases are shown graphically in Figures 5-5 through 5-9 and are tabulated in Appendix A-2. Continuous data were only collected during periods when MM5 sampling was being conducted.

Review of the data in Figures 5-5 and 5-6 shows a slightly higher variability in O_2 and CO concentrations during Runs 2 and 3 relative to Runs 1 and 4. This higher variability is expected because of unsteady incinerator operation on these test days. No other significant trends in flue gas parameter variation with incinerator operating conditions are evident from the data as presented in Figures 5-5 through 5-9.

5.3 FLUE GAS PARAMETER DATA

Table 5-6 summarizes flue gas temperature, moisture, volumetric flow rate, and oxygen concentration data obtained for incinerator ISW-A. These parameters were fairly consistent between the four test runs shown. The average flue gas temperature and moisture contents (based on Runs 1, 3, and 4)

Prior to Run 4 (Figure 5-4), the ash in the incinerator was allowed to burn down for approximately 24 hours and all of the ash was removed. No incinerator operating problems were encountered during the test.

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TABLE 5-4. SUMMARY OF CONTINUOUS MONITORING RESULTS FOR INCINERATOR ISW-A

Parameter	Run Number 1 Mean Value (Standard Deviation)	Run Number 2 Mean Value (Standard Deviation)	Run Number 3 Mean Value (Standard Deviation)	Run Number 4 Mean Value (Standard Deviation)
Oxygen (volume %)	10.5 (1.3)	11.8 (1.7)	11.6 (1.6)	11.7 (1.4)
Carbon monoxide (ppmv)[a]	369 (59.4)	122 (55.0)	147 (72.6)	146 (52.6)
Carbon dioxide (volume %)	9.2 (1.3)	8.3 (1.7)	8.3 (1.4)	7.8 (1.5)
Nitrogen oxides (ppmv)	77.4 (23.9)	66.1 (21.5)	72.7 (20.1)	59.1 (16.7)
Total hydrocarbons (ppmv)[b]	NA[c]	5.9 (1.5)	2.8 (0.6)	2.2 (1.1)

[a] ppmv = parts per million by volume.

[b] Parts per million by volume as propane.

[c] Not available due to instrument malfunction.

TABLE 5-5. SUMMARY OF CONTINUOUS MONITORING RESULTS FOR INCINERATOR ISW-A AT 3% OXYGEN

Parameter	Run Number 1 Mean Value (Standard Deviation)	Run Number 2 Mean Value (Standard Deviation)	Run Number 3 Mean Value (Standard Deviation)	Run Number 4 Mean Value (Standard Deviation)
Oxygen (volume %)	10.5 (1.3)	11.8 (1.7)	11.6 (1.6)	11.7 (1.4)
Carbon monoxide (ppmv)[a]	645 (140)	248 (122)	298 (166)	289 (109)
Carbon dioxide (volume %)	15.9 (1.4)	16.4 (1.8)	16.2 (1.7)	15.2 (1.6)
Nitrogen oxides (ppmv)	131 (29.8)	130 (31.2)	138 (25.3)	114 (20.2)
Total hydrocarbons (ppmv)[b]	NA[c]	12.0 (3.6)	5.3 (1.7)	4.3 (2.0)

[a] ppmv = parts per million by volume.

[b] Parts per million by volume as propane.

[c] Not available due to instrument malfunction.

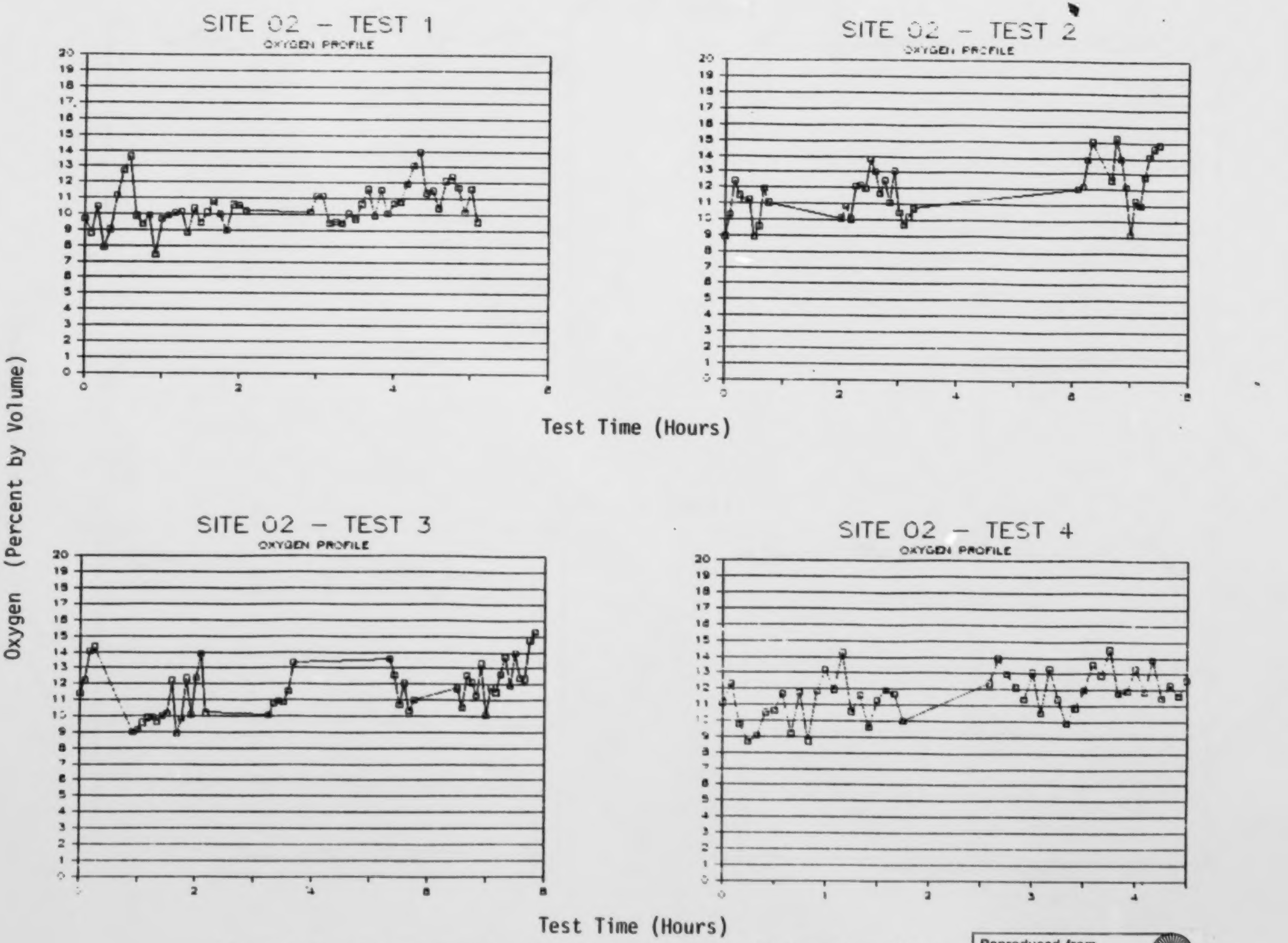

Figure 5-5. Oxygen Concentrations vs. Time For Incinerator ISW-A

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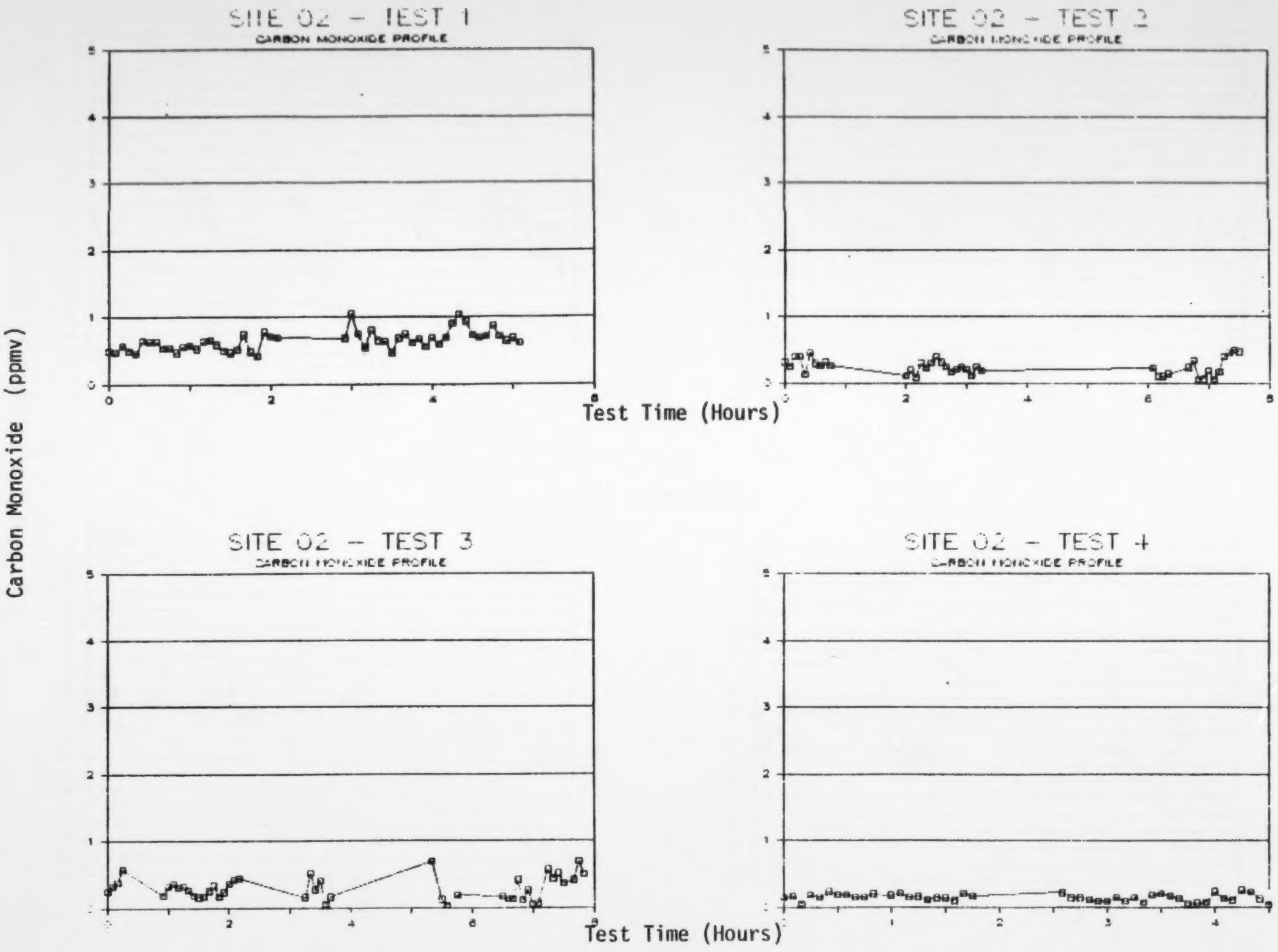
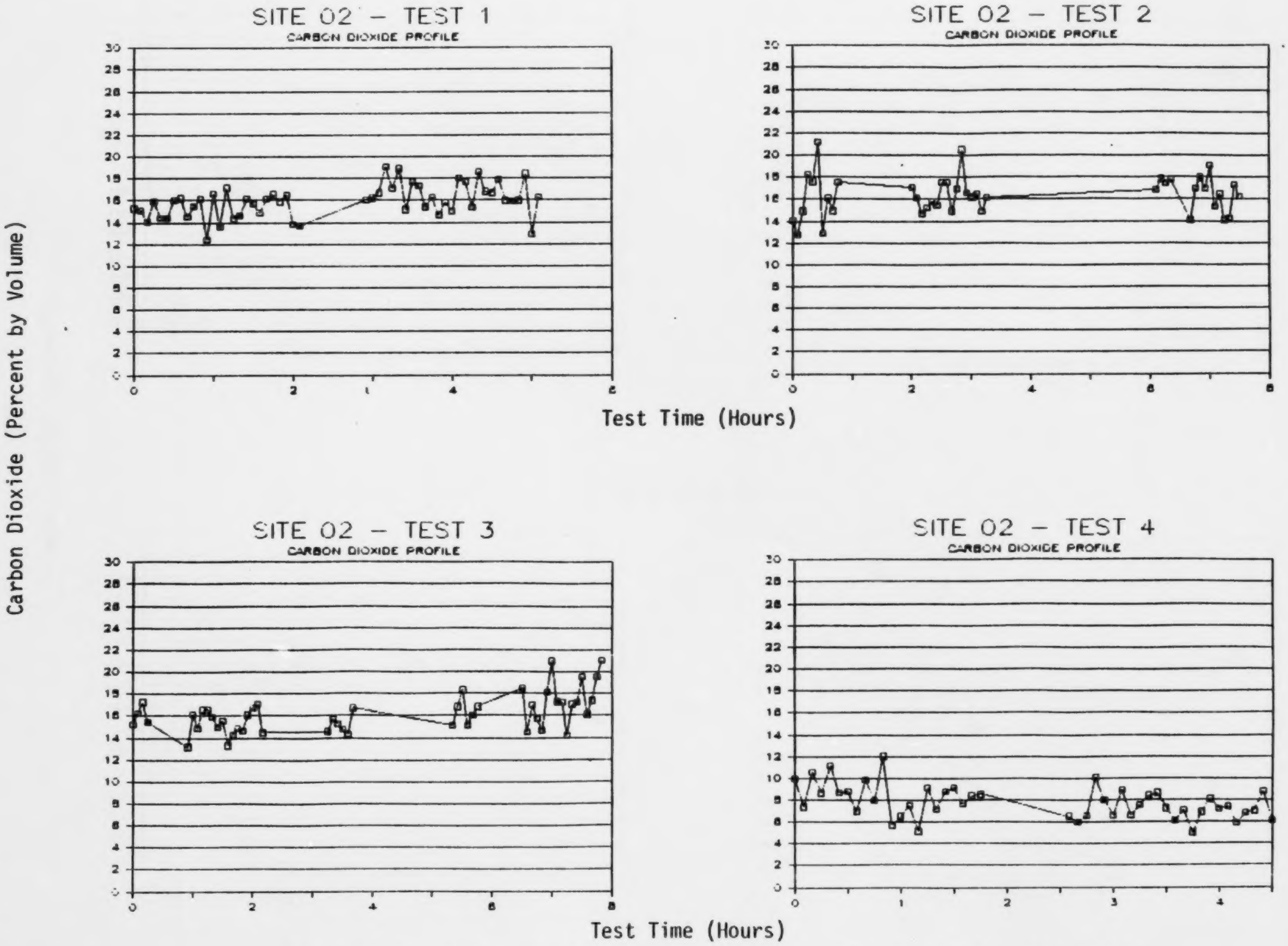


Figure 5-6. Carbon Monoxide Concentrations vs. Time for Incinerator ISW-A


SITE 02 - TEST 1
CARBON DIOXIDE PROFILE

SITE 02 - TEST 2
CARBON DIOXIDE PROFILE

SITE 02 - TEST 3
CARBON DIOXIDE PROFILE

SITE 02 - TEST 4
CARBON DIOXIDE PROFILE

Figure 5-7. Carbon Dioxide Concentrations vs. Time for Incinerator ISW-A

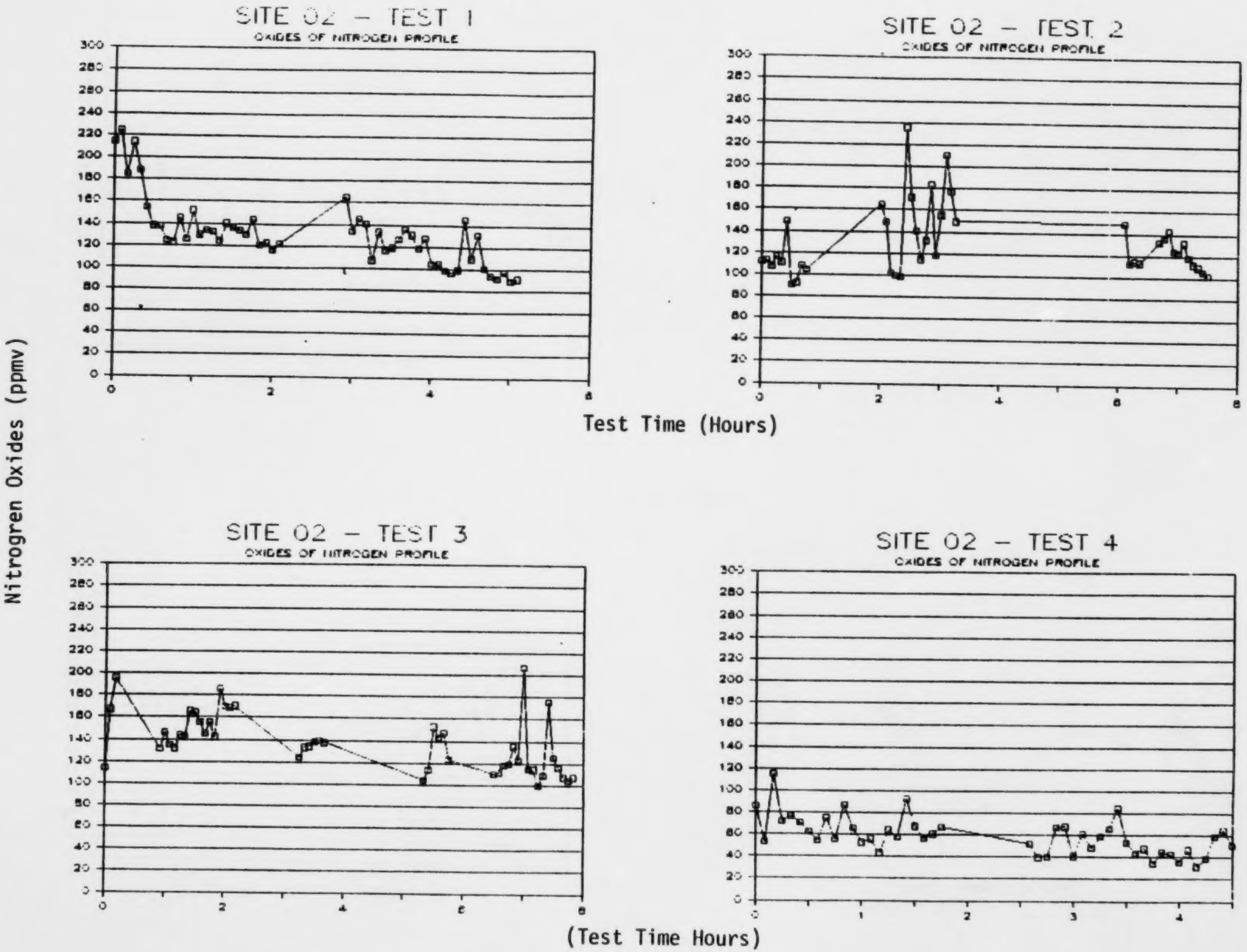


Figure 5-8. Nitrogen Oxides Concentration vs. Time for Incinerator ISW-A

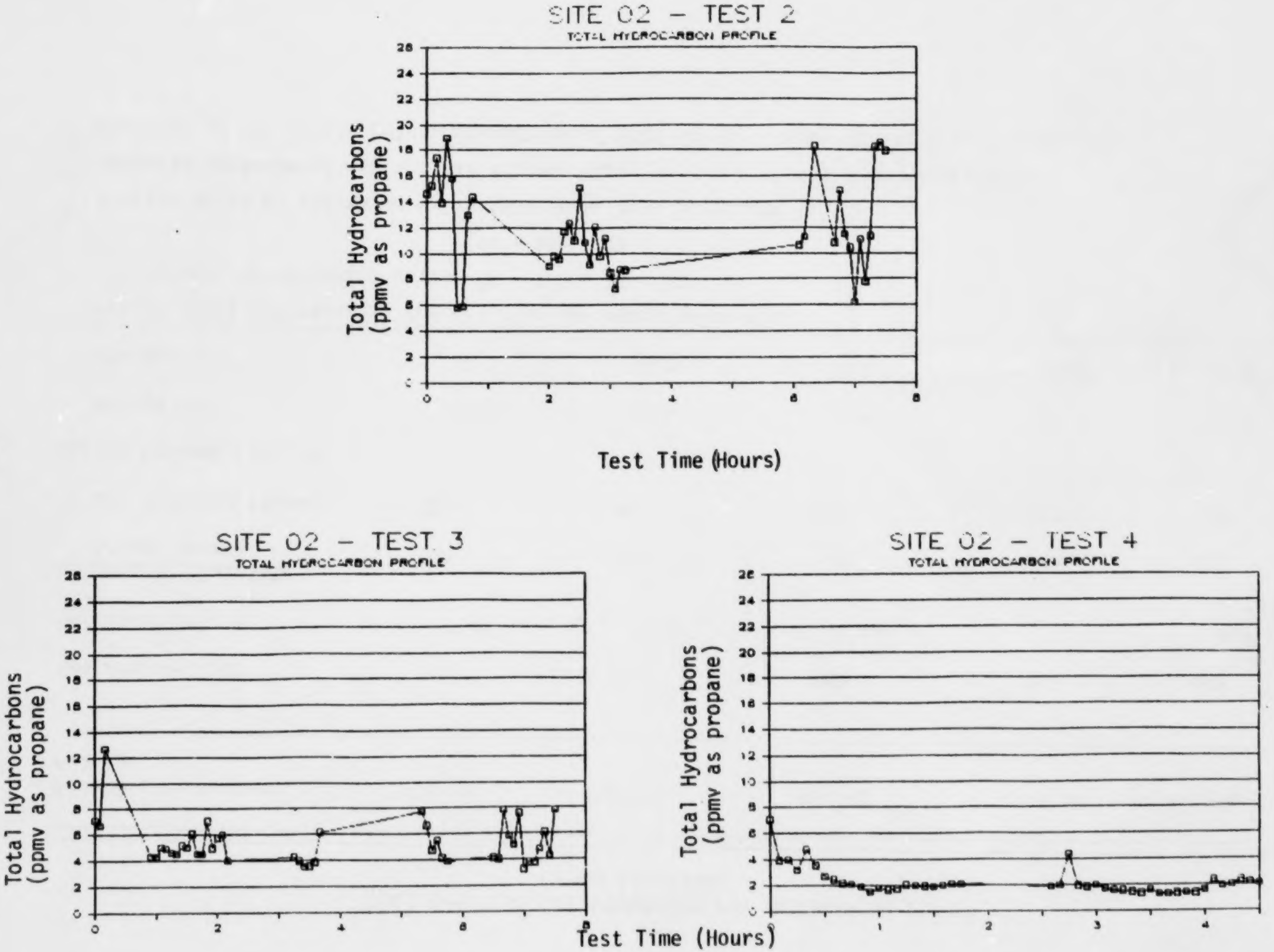


Figure 5-9. Total Hydrocarbon Concentrations vs. Time for Incinerator ISW-A

TABLE 5-6 FLUE GAS PARAMETERS FOR INCINERATOR ISW-A[a]
(STACK LOCATION)

Flue Gas Parameters Average	Run 01	Run 02	Run 03	Run 04	Average[b]
Temperature (°C)	142	158	187	177	169
Moisture (vol. %)	7.45	7.62	8.44	7.72	7.87
Volumetric Flow Rate					
Actual (acmm)	391	435	399	398	396
Dry Standard (dscmm)	250	267	227	237	238
Oxygen Content (vol. %)					
Radian CEM[c]	10.5	11.8	11.6	11.7	11.3
EPA Method 3[d]	17.6	18.2	16.6	18.2	17.5

[a] Metric units are reported for all flue gas measurement data.

To convert to alternate units: $^{o}F = 1.8 \times {}^{o}C + 32$

$cfm = cmm \times 35.3$

[b] Average based on the three valid test runs, Runs 1, 3, and 4.

[c] Measured upstream of ambient air intake damper on stack (Point D on Figure 4-1).

[d] Measured at MM5 sample point, downstream of ambient air damper (Point E on Figure 4-1).

measured at the exhaust stack location were 169°C (336°F) and 7.9 percent by volume, respectively. The average exhaust gas flow rate under actual stack temperature and moisture conditions was 396 acmm (13,990 acfm), and the average dry, standard flow rate was 238 dscmm (8,410 dscfm). Standard EPA conditions are 20°C (68°F) and 1 atm.

Flue gas oxygen concentration data were obtained both upstream and downstream of the ambient air intake damper on the stack. Oxygen concentrations measured downstream of the damper by EPA Method 3 showed an average of 11.3 percent for the three valid test runs. Upstream of the damper, CEM analyses showed an average oxygen concentration of 17.5 percent.

5.4 DIOXIN/FURAN EMISSIONS DATA

Emission concentrations and emission rates determined for 2378 TCDD, total PCDD, and total PCDF during Runs 1, 3 and 4 are shown in Table 5-7. Data presented in Table 5-7 include the total dioxin/furan collected in the MM5 sample train (probe, filter, XAD sorbent trap and impingers). Analytical values obtained for each MM5 train were not corrected for blanks. Surrogate recoveries and blank sample train results are discussed in Section 8.0.

Dioxin/furan results for Run 2 were similar to those for Run 1, with mass emission rates of 8.62, 1,370 and 4,600 ug/hr for 2378 TCDD, total PCDD, and total PCDF respectively. As discussed previously in Section 5.1, the MM5 sample for Run 2 was analyzed to provide dioxin/furan emissions data on unsteady or frequently interrupted operation. The similarity in emission rates for Runs 1 and 2 suggests that unsteady operation has no effect on dioxin/furan emissions from incinerator ISW-A. Sampling and analytical data for Run 2 are included with data for Runs 1, 3, and 4 in the appendices of this report. No further discussion of Run 2 results will be provided in this section.

As shown in Table 5-7, mass emissions of 2378 TCDD for the three valid test runs varied from 6.18 to 20.0 mg/hr. The highest emission rate was measured for Run 3 and the lowest was for Run 1. In comparing the 2378 TCDD emission rate data to process data presented in Section 5.1, it is noted that

TABLE 5-7. SUMMARY OF DIOXIN AND FURAN EMISSION CONCENTRATION AND EMISSION RATE DATA FOR SITE ISW-A (STACK LOCATION)

Run Number	2378 TCDD	Total PCDD	Total PCDF
Emission Rate (ug/hr)			
Run 01	6.18	1,070	5,010
Run 03	20.0	2,280	7,290
Run 04	14.4	2,080	8,030
Average	13.5	1,810	6,780
Emissions Concentration at actual O_2, ng/dscm			
Run 01	0.41	72	334
Run 03	1.47	168	536
Run 04	1.01	146	565
Average	0.96	129	478
Emissions Concentration (corrected to 3% O_2), ng/dscm			
Run 01	2.17	378	1,760
Run 03	4.89	557	1,780
Run 04	6.52	940	3,630
Average	4.53	625	2,390

---

[a] Flue gas concentration data corrected to 3% O_2 using the EPA Method 3 data presented in Table 5-6.

Run 3 also corresponds to the test condition for which the feed rate of wood/plastic cutoffs was highest and Run 1 corresponds to the condition with the lowest wood/plastic cutoffs feed rate.

Emissions rates for total PCDD and total PCDF were similar for Runs 2 and 3 and comparatively lower for Run 1. No trends in total PCDD or total PCDF with process conditions were noted.

Isomer- and homologue-specific emission concentration data are summarized in Tables 5-8 and 5-9 for the three valid test runs. Run-specific data tables showing homologue emission concentrations in both ng/dscm and part-per-trillion units and homologue emission rates in ug/hr units are included in Appendix D. Detectable quantities were found of each isomer and homologue analyzed for incinerator ISW-A. Figure 5-10 is a histogram that shows the relative distributions of the 2378 TCDD/TCDF isomers and the tetra-through octa PCDD/PCDF homologues in the exhaust stack emissions (mole basis). The distribution of dioxin/furan isomers was similar for each of the test runs. For dioxin isomers, the contribution of individual homologues increased with increasing chlorination up to the hepta-CDD. The contributions of the tetra- through octa-chlorinated dioxin homologues to the total PCDD emissions were: tetra, 12.4-19.7%; penta, 16.0-21.1%; hexa, 21.2-28.5%; hepta, 27.2-40.0%; and octa, 6.6-11.9% on a mole basis. For furan isomers, the contribution of individual homologues decreased slightly with increasing chlorination. The contributions of the tetra- through octa-chlorinated furan homologues to the total PCDF were: tetra, 25.1-32.5%; penta, 22.8-27.6%; hexa, 23.0-32.9%; hepta, 14.3-18.5%; octa, 1.7-2.7%.

Emission factors based on incinerator feed rates are shown in Table 5-10. Average emission factors were: 0.013 ug 2378 TCDD per Kg of feed; 1.7 ug total PCDD per Kg of feed and 6.3 ug total PCDF per Kg of feed.

5.5 HCl TRAIN CHLORIDE EMISSIONS DATA

Table 5-11 summarizes HCl train chloride emissions data measured at the exhaust stack sampling location. The data are reported as "front half," "back half," and "train total" chloride emissions. The front-half emissions

TABLE 5-8. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA FOR SITE ISW-A
(At Actual Stack Oxygen Concentration)

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm)			
	Run 01	Run 03	Run 04	Avg.
DIOXINS				
2378 TCDD	4.12E-01	1.47E+00	1.01E+00	9.67E-01
Other TCDD	6.80E+00	2.61E+01	1.68E+01	1.66E+01
Penta-CDD	1.03E+01	3.26E+01	2.29E+01	2.20E+01
Hexa-CDD	2.02E+01	3.94E+01	3.08E+01	3.01E+01
Hepta-CDD	2.41E+01	5.03E+01	6.33E+01	4.59E+01
Octa-CDD	9.90E+00	1.77E+01	1.14E+01	1.30E+01
Total PCDD	7.18E+01	1.68E+02	1.46E+02	1.29E+02
FURANS				
2378 TCDF	2.27E+00	6.53E+00	4.46E+00	4.42E+00
Other TCDF	6.95E+01	1.46E+02	1.36E+02	1.17E+02
Penta-CDF	7.24E+01	1.43E+02	1.50E+02	1.22E+02
Hexa-CDF	1.15E+02	1.32E+02	1.41E+02	1.30E+02
Hepta-CDF	6.37E+01	8.97E+01	1.21E+02	9.15E+01
Octa-CDF	1.09E+01	1.83E+01	1.24E+01	1.39E+01
Total PCDF	3.34E+02	5.36E+02	5.65E+02	4.78E+02

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

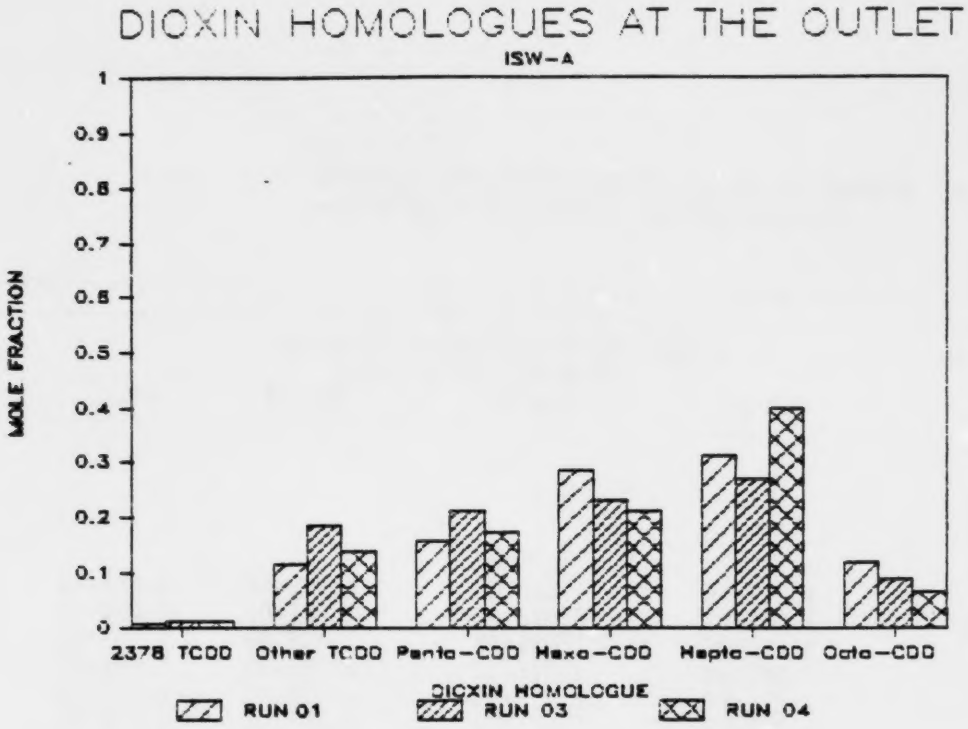
ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
2200 operating hours per year

TABLE 5-9. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA FOR SITE ISW-A
(Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm @ 3% oxygen)			
	Run 01	Run 03	Run 04	Avg.
DIOXINS				
2378 TCDD	2.17E+00	4.89E+00	6.52E+00	4.53E+00
Other TCDD	3.58E+01	8.67E+01	1.08E+02	7.69E+01
Penta-CDD	5.43E+01	1.08E+02	1.47E+02	1.03E+02
Hexa-CDD	1.06E+02	1.31E+02	1.98E+02	1.45E+02
Hepta-CDD	1.27E+02	1.67E+02	4.07E+02	2.34E+02
Octa-CDD	5.21E+01	5.87E+01	7.30E+01	6.13E+01
Total PCDD	3.78E+02	5.57E+02	9.40E+02	6.25E+02
FURANS				
2378 TCDF	1.19E+01	2.17E+01	2.87E+01	2.08E+01
Other TCDF	3.66E+02	4.84E+02	8.74E+02	5.74E+02
Penta-CDF	3.81E+02	4.76E+02	9.64E+02	6.07E+02
Hexa-CDF	6.08E+02	4.40E+02	9.08E+02	6.52E+02
Hepta-CDF	3.35E+02	2.98E+02	7.78E+02	4.71E+02
Octa-CDF	5.75E+01	6.08E+01	7.95E+01	6.60E+01
Total PCDF	1.76E+03	1.78E+03	3.63E+03	2.39E+03

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
2200 operating hours per year



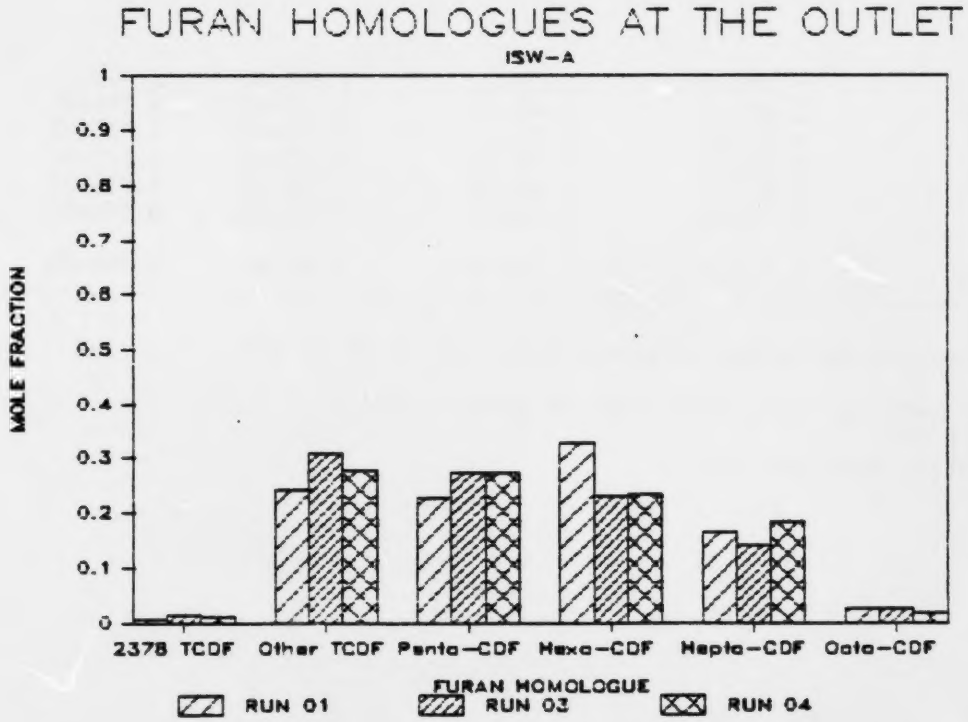


Figure 5-10. Dioxin/Furan Homologue Distribution for Site ISW-A

TABLE 5-10. DIOXIN/FURAN EMISSION FACTORS FOR SITE ISW-A

Dioxin/Furan Isomer	Dioxin/Furan Emission Factors (ug/kg)			
	Run 01	Run 03	Run 04	Avg.
DIOXINS				
2378 TCDD	5.69E-03	2.12E-02	1.18E-02	1.29E-02
Other TCDD	9.39E-02	3.75E-01	1.97E-01	2.22E-01
Penta-CDD	1.42E-01	4.69E-01	2.68E-01	2.93E-01
Hexa-CDD	2.79E-01	5.66E-01	3.60E-01	4.01E-01
Hepta-CDD	3.33E-01	7.23E-01	7.39E-01	5.98E-01
Octa-CDD	1.37E-01	2.54E-01	1.33E-01	1.74E-01
Total PCDD	9.90E-01	2.41E+00	1.71E+00	1.70E+00
FURANS				
2378 TCDF	3.13E-02	9.38E-02	5.21E-02	5.91E-02
Other TCDF	9.58E-01	2.09E+00	1.59E+00	1.55E+00
Penta-CDF	9.98E-01	2.06E+00	1.75E+00	1.60E+00
Hexa-CDF	1.59E+00	1.90E+00	1.65E+00	1.71E+00
Hepta-CDF	8.79E-01	1.29E+00	1.41E+00	1.19E+00
Octa-CDF	1.51E-01	2.63E-01	1.45E-01	1.86E-01
Total PCDF	4.61E+00	7.70E+00	6.60E+00	6.30E+00

ND = not detected (detection limit in parentheses).
ug = 1.0E-06g
2200 operating hours per year

TABLE 5-11. HCl TRAIN CHLORIDE EMISSIONS DATA FOR SITE ISW-A (STACK LOCATION)

Sample Portion	Test Run	TOTAL CHLORIDE mg/dscm	ppmv[a]	mg/dscm[b] @ 3% O_2	Kg/hr
Train Total	01	1,500	1,015	8,140	22.2
	03	2,540	1,720	13,800	35.8
	04	1,890	1,280	10,300	27.1
	Average	1,980	1,340	10,700	28.4
Front Half	01	31.5	21.3	171	0.46
	03	51.0	34.5	277	0.72
	04	10.2	6.9	55.3	0.15
	Average	30.9	20.9	168	0.44
Back Half	01	1,470	994	7,970	21.7
	03	2,490	1,680	13,500	35.1
	04	1,880	1,270	10,200	26.9
	Average	1,950	1,315	10,600	27.9

[a] ppmv = parts per million by volume chloride, dry basis at actual stack O_2 concentration.

[b] Concentration corrected to 3% O_2 using the equation:

$[Cl^-]$ @ 3% O_2 = $[Cl^-]$, as measured × (20.9 - 3)/(20.9 - % O_2)

where: % O_2 = oxygen concentration in stack gas as measured by EPA Method 3.

represent chlorides captured in the probe rinse/filter fraction of the HCl train and consist of metal chlorides contained in the particulate matter. The back-half emissions represent gaseous HCl captured in the sample train impingers. The train-total emissions represent the sum of the front half and back half emissions.

As shown in Table 5-11, the average train-total chloride emissions concentration at stack oxygen levels was approximately 1980 mg/dscm. Corrected to 3% O_2 using the Radian EPA Method 3 data, this corresponds to approximately 10,700 mg/dscm @ 3% O_2. The average train-total chloride mass emission rate from the waste heat boiler exhaust stack was about 28.4 kg/hr (62.6 lb/hr). More than 98 percent of the chlorides was gaseous HCl.

Chloride emissions ranged from 22.2 to 35.8 Kg/hr (48.8 to 78.8 lb/hr) for the three test runs. The highest chloride emission rate was for Run 3, which also showed the highest 2378 TCDD emission rate and had highest feed rate of wood/plastic cutoffs. Similarly, the lowest chloride emission rate was for Run 1 which showed the lowest 2378 TCDD emissions and had the lowest wood/plastic cutoffs feed rate.

5.6 INCINERATOR ASH DIOXIN/FURAN

Table 5-12 shows the run-specific data for the bottom ash samples from Site ISW-A. The dioxin/furan concentrations varied considerably between the three runs for which ash samples were analyzed. The Run 03 and 04 ash samples contained considerably more dioxin/furan than the ash sample collected during Run 01. The feed during Runs 03 and 04 contained higher percentages of wood/plastic cutoff which could have contributed to the high dioxin/furan concentrations in the ash. In addition, during Run 03 the chain-link conveyor which removes ash from the incinerator failed. The incinerator was operated until the ash build-up had to be removed. Operating in this mode may have contributed to the higher dioxin/furan concentrations observed for Run 03.

TABLE 5-12. DIOXIN/FURAN CONTENTS OF INDIVIDUAL BOTTOM ASH SAMPLES FROM SITE ISW-A

Isomer/ Homologue	Dioxin/Furan Homologue Contents (ppb)			
	Run 01	Run 03	Run 04	Average
Dioxins				
2378-TCDD	NR	0.2	0.1	0.2
Other TCDD	ND	1.9	1.6	1.2
Penta CDD	ND	2.7	5.0	2.6
Hexa CDD	0.2	28.4	10.9	13.2
Hepta CDD	0.5	126.2	44.1	56.9
Octa-CDD	0.4	143.2	56.6	66.7
Total PCDD	1.1	302.6	118.3	140.7
Furans				
2378-TCDF	NR	ND	ND	--
Other PCDF	ND	1.2	0.5	0.6
Penta CDF	ND	0.9	0.3	0.4
Hexa CDF	ND	2.6	0.7	1.1
Hepta CDF	0.04	7.8	1.9	3.2
Octa-CDF	0.03	5.2	1.4	2.2
Total PCDF	0.07	17.7	4.8	7.5

ND = Not detected. Analytical detection limits ranged from 10 parts per trillion to 80 parts per trillion for specific homologues.
NR = Not reported by Troika.

5.7 DIOXIN/FURAN PRECURSORS

As discussed in Section 4.0, five different incinerator feed samples were collected during testing at Site ISW-A, including: wood/paper/cardboard, wood/plastic cutoffs, latex (water based) paint sludge, "hytest" (oil based) paint sludge, and fuel oil. The first four of these samples were analyzed for chlorobenzenes, chlorophenols and chlorinated biphenyls.

In addition, composite feed samples and the fuel oil were analyzed for total chloride and total organic halide.

The results of compound specific precursor analyses are summarized in Table 5-13. As shown in Table 5-13, the only precursors consistently found in the feed materials were tetrachloro and pentachlorophenols. The highest quantities of chlorinated phenols (5.8 to 19.7 ppm) were found in the wood/plastic cutoffs. Analysis results were not reported for chlorinated biphenyls and chlorinated benzenes in some samples because adequate sample extraction and cleanup procedures could not be developed within the time and budget constraints of this program.

Results for total chlorine and organic halide (TOX) determinations are summarized in Table 5-14. Total chlorine concentrations of 22.0 and 20.4 ppm were found in the fuel oil for Runs 01 and 03 respectively. No chlorine was detected in the fuel oil for Run 04. No organic halides were detected in fuel oils for Runs 3 and 4, but a concentration of 22.2 ppm was reported for Run 2.

The total chlorine analysis for the composite feed sample showed 9670 ppm and the TOX analysis showed 12.7 ppm, suggesting that most of the chlorine in the feed is inorganic chlorine. This is an expected result because the greatest source of chlorine in the feed is from PVC.

5.8 AMBIENT AIR AND SOILS DIOXIN/FURAN DATA

The ambient air and soil samples were archived pending evalaution of analytical data.

TABLE 5-13. SUMMARY OF GC/MS PRECURSOR ANALYSES ON FEED SAMPLES

		Precursor Concentration (ppm by weight, mg/kg of waste)			
				Paint Sludges	
Test Run	Precursor Compounds	Wood/ Plastic Cutoff	Crate, Wood, Paper, Cardboard	Latex	Hytest
01	TOTAL CHLORINATED PHENOLS	19.7	0.11	trace	ND[a]
	-Tetrachloro phenol	12.5	-	-	-
	-Pentachloro phenol	7.2	0.11	trace	-
03	TOTAL CHLORINATED PHENOLS	5.8	NA	0.02	ND
	-Tetrachloro phenol	1.1		-	-
	-Pentachloro phenol	4.7		0.02	
04	TOTAL CHLORINATED PHENOLS	6.2	0.04	0.03	-
	-Tetrachloro phenol	1.1	-	-	-
	-Pentachloro phenol	5.1	0.04	0.03	0.03
01	TOTAL CHLORINATED BIPHENYLS	ND	ND	NR[c]	NR
03	TOTAL CHLORINATED BIPHENYLS	NR	ND	NR	NR
04	TOTAL CHLORINATED BIPHENYLS	NR	ND	NR	NR
01	TOTAL CHLORINATED BENZENES	ND	ND	NR	NR
03	TOTAL CHLORINATED BENZENES	NR	ND	NR	NR
04	TOTAL CHLORINATED BENZENES	NR	ND	NR	NR

[a] ND = not detected, detection limit was approximately 0.02 parts per million.

[b] NA = not analyzed.

[c] NR = values not reported. Adequate sample extraction and cleanup procedures not available.

TABLE 5-14. SUMMARY OF TOTAL CHLORIDE AND TOTAL ORGANIC HALIDE DATA

Sample Type	Test Run	Total Chloride (ppm)[a]	Total Organic Halogen (ppm)[a]
Fuel Oil	01	22.0	NA[b]
	02	NA	22.2
	03	20.4	ND[c]
	04	ND[d]	ND
Composite Feed[e]	04	9,670	12.7

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[a] ppm = parts per million, weight basis (ug/g), blank corrected.

[b] NA = not analyzed.

[c] Not detected at 4 ppm detection limit.

[d] Not detected at 10 ppm detection limit.

[e] Composite feed consisting of 90 weight percent wood/paper/cardboard and 10 percent wood/plastic cutoffs.

6.0 SAMPLING LOCATIONS AND PROCEDURES

Samples were collected from seven different locations around the Site ISW-A incinerator. The specific sampling locations are shown in Figure 6-1. Three of the locations were for gaseous sampling, one was for liquid sampling, and three were for slurry and/or solid sampling. The source sampling and analysis matrix in Table 6-1 shows the sample location, the measured parameters, the sampling methods, and the analysis method.

Details on the sampling locations and methods are discussed in Sections 6.1 through 6.3. Analytical procedures for the continuous monitoring samples (CO, CO_2, O_2, THC, and NO_x) and the molecular weight determinations are included in Section 6.1. All other analytical procedures are discussed in Section 7.

6.1 GASEOUS SAMPLES

Four tyes of gaseous samples were taken during the testing: Modified Method 5 (MM5), HCl, ambient air, and continuous monitoring (CEM). The sampling locations and methods are further discussed in this section.

6.1.1 Gaseous Sampling Locations

6.1.1.1 Outlet Exhaust Stack Location. The system outlet exhaust stack location is shown as Point E in Figure 6-1. This location was used for dioxin/furan sampling using MM5 and for gas velocity, molecular weight, and moisture determinations using EPA Methods 1 through 4.

Dimensions of the outlet exhaust stack sampling location relative to the nearest flow disturbances are shown in Figure 6-2. The sampling ports were located 4.3 duct diameters downstream of the ambient air intake damper and 6 diameters upstream of the top of the stack. Based on EPA Method 1, a total of 24 traverse points were required for velocity determination at this location.

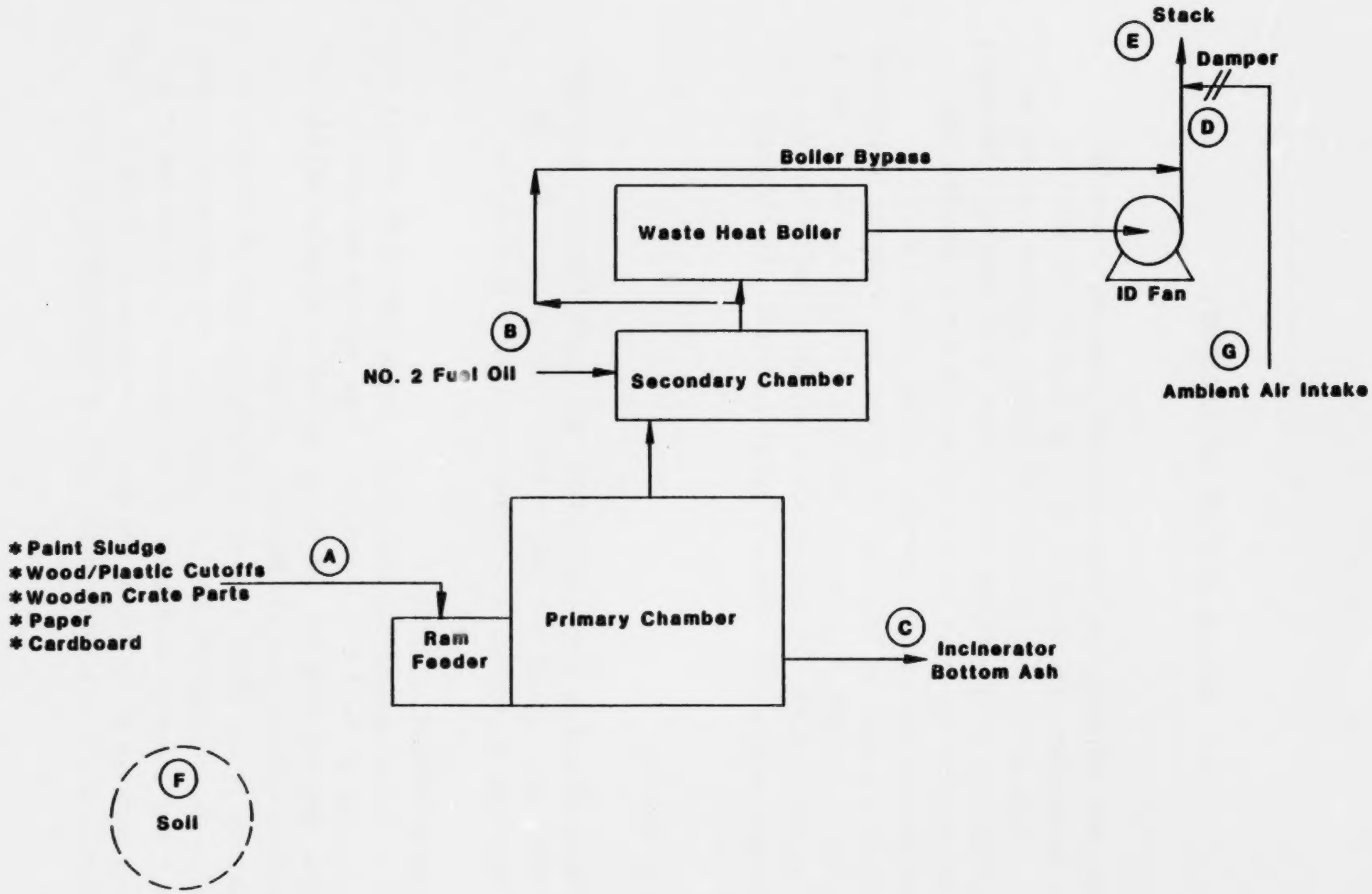
Stack
E
Damper
D
Boiler Bypass
Waste Heat Boiler
ID Fan
B
NO. 2 Fuel Oil
Secondary Chamber
G
Ambient Air Intake
* Paint Sludge
* Wood/Plastic Cutoffs
* Wooden Crate Parts
* Paper
* Cardboard
A
Ram Feeder
Primary Chamber
C
Incinerator Bottom Ash
F
Soil

Figure 6-1. Process flow diagram and sample locations for Site ISW-A

Table 6-1. Source Sampling and Analysis Matrix - Site ISW-A

Sample Location	Sample Type or Parameter	Sampling Method	Analysis Method	Number of Samples or Frequency
System outlet exhaust stack (point E on Figure 6-1)	Dioxin, furan	Modified EPA Method 5 (MM5)	Gas chromatograph/mass spectometeter	Four test runs[a]; one per test day.
	Volumetric flow	EPA Method 2	NA[b]	Once per MM5 test run.
	Molecular weight	EPA Method 3	Gas chromatograph/thermal conductivity detector	Six to eight integrated bag samples per MM5 test run.
	Moisture	EPA Method 4	Gravimetric balance	Once per MM5 test run.
	HCl	HCl acid train	Ion chromatograph	Once per MM5 test run.
Boiler outlet sample location (point D on Figure 6-1)	CO/CO_2	In-stack filter probe and heat-traced Teflon^{R} line	Nondispersive infrared analyzer	Continuously during MM5 test runs.
	O_2	Same as CO/CO_2	Paramagnetic analyzer	Continuously during MM5 test runs.
	NO_x	Same as CO/CO_2	Chemiluminescent analyzer	Continuously during MM5 test runs.
	Total hydrocarbons (THC)	Same as CO/CO_2	Flame ionization analyzer[c]	Continuously during MM5 test runs.
Ambient Air	Dioxin, furan	Ambient air/XAD resin train	Gas chromatograph/mass spectrometer	One sample taken continuously during four MM5 test runs.
Incinerator feed material	Wood/wood crate parts/paper/cardboard for dioxin, furan, and dioxin precursors	Grab samples	Gas chromatograph/mass spectrometer	Duplicate composite or integrated sample for each MM5 test run.
	Wood/PVC cutoffs for dioxin, furan, and dioxin precursors	Grab samples	Gas chromatograph/mass spectrometer	Two grab samples of sawdust and one grab sample of pieces per MM5 test run.
	Latex paint sludge for dioxin, furan, and dioxin precursors	Grab samples	Gas chromatograph/mass spectrometer	Duplicate composite samples from two buckets; once per MM5 test run.
	Hytest paint sludge for dioxin, furan, and dioxin precursors	Grab samples	Gas chromatograph/mass spectrometer	Duplicate composite samples from two buckets; once per MM5 test run.

Table 6-1. Source Sampling and Analysis Matrix - Site TSW-A

Sample Location	Sample Type or Parameter	Sampling Method	Analysis Method	Number of Samples or Frequency
Ash conveyor/hopper	Bottom ash for dioxin, furan	Grab samples	Gas chromatograph/mass spectrometer	Once during MM5 test runs.
Ash handling area	Soils for dioxin, furan	Grab samples	Gas chromatograph/mass spectrometer	One composite of 10 samples.
Oil feed line	Fuel oil for total chlorine, dioxin, furan and dioxin precursors	Tap valve sample	Gas chromatograph/mass spectrometer	Triplicate composite grab samples for each test run.

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[a] The second test run was aborted after completing 17 of 24 traverse points due to failure of a hydraulic oil line on the incinerator feed ram.

[b] NA = not applicable.

[c] The flame ionization analyzer was calibrated using propane standards.

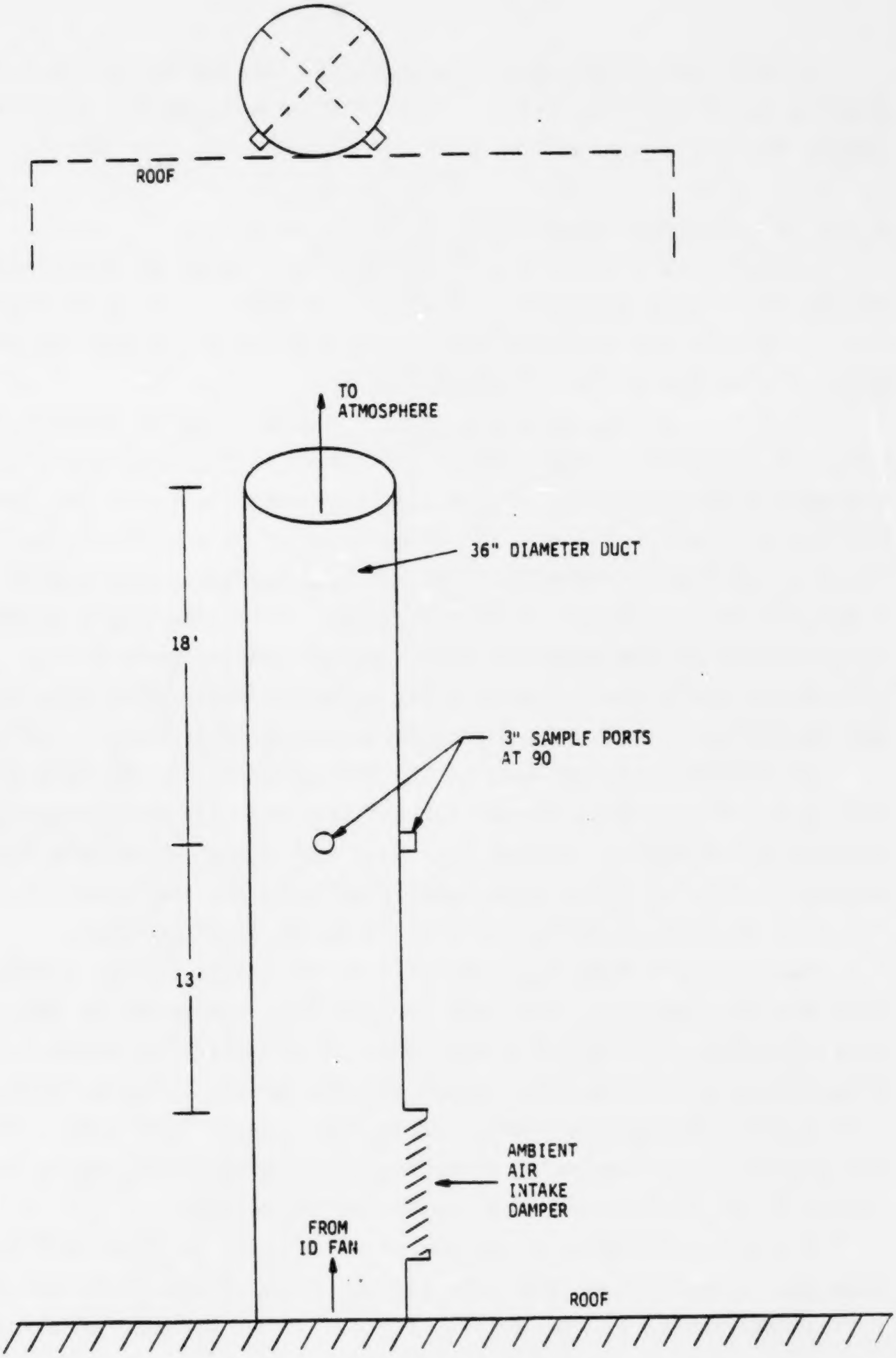

ROOF
TO ATMOSPHERE
36" DIAMETER DUCT
18'
3" SAMPLE PORTS AT 90
13'
AMBIENT AIR INTAKE DAMPER
FROM ID FAN
ROOF

Figure 6-2. System exhaust stack sample location.

6.1.1.2 Boiler Outlet Sample Location. The boiler outlet location is shown as point D in Figure 6-1. This location was used for obtaining a gas sample for continuous monitoring of O_2, CO_2, CO, NO_x, and THC.

6.1.2 Gas Sampling Procedures

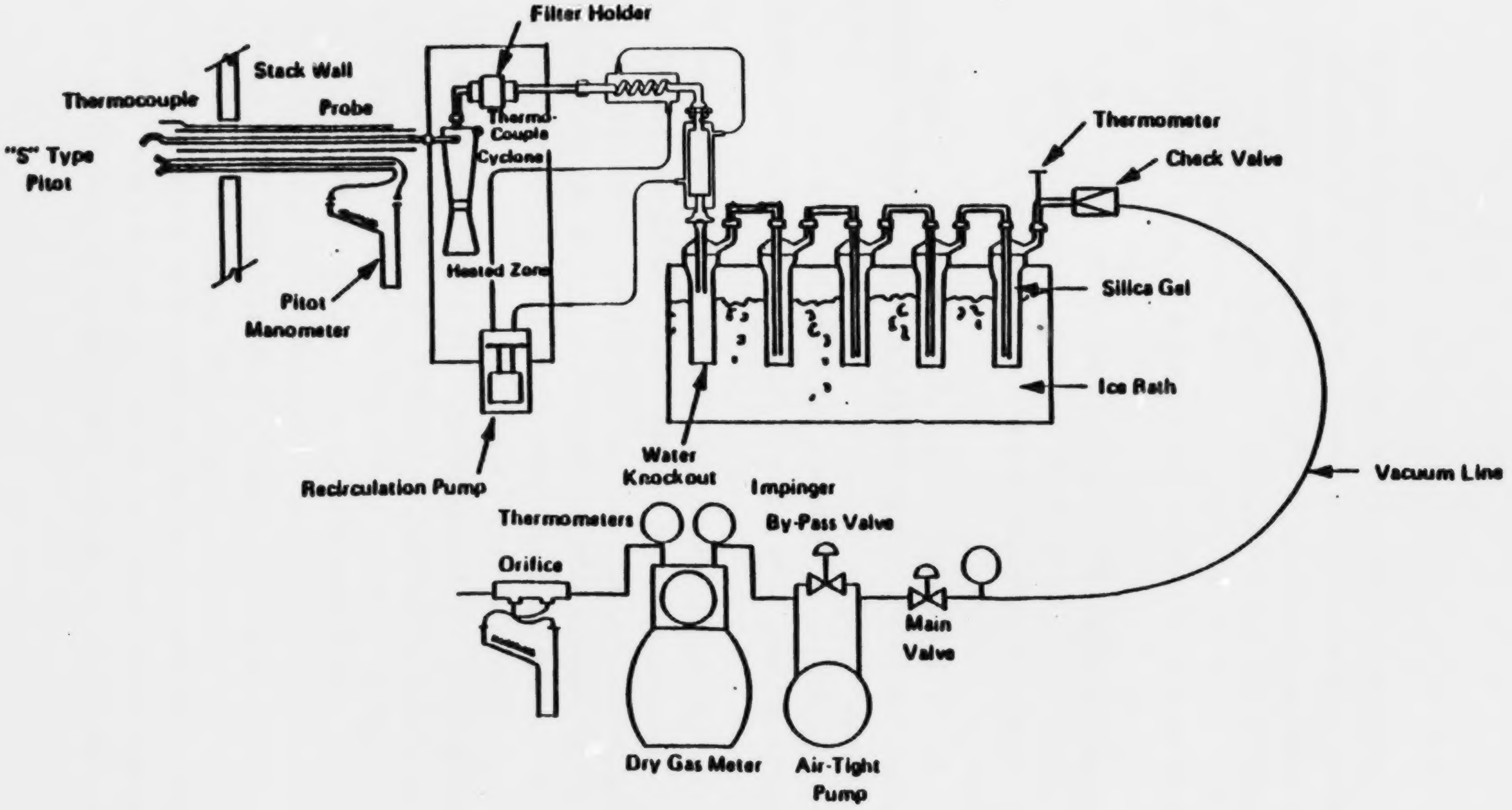
Gas sampling procedures used during this program are discussed in detail in the Tier 4 Quality Assurance Project Plan (QAPP).[1] A brief description of each method and any necessary deviations from the procedures outlined in the QAPP are provided in the following sections.

6.1.2.1. Modified Method 5 (MM5). Gas sampling for dioxins was conducted according to the October 1984 draft of the ASME chlorinated organic compound sampling protocol. This sampling method is a modified version of EPA Method 5 that includes a condenser followed by a solid sorbent module for trapping vapor phase organics. The MM5 sampling train was used to collect samples at the system outlet exhaust stack. Following sample recovery, the various parts of the sample (filter, solvent rinses, sorbent trap, etc.) were sent to the EPA's Troika laboratories to quantify the 2378-TCDD, 2378-TCDF, and the tetra- through octa-dioxin/furan homolgues present in the samples.

One modification was made to the ASME protocol for the Site ISW-A test: the condenser preceding the XAD sorbent trap was oriented horizontally instead of vertically. Radian has found that substitution of a horizontal condenser (but not trap) works equally well and has the added advantage of reducing the space required for traversing the sampling train.

Four MM5 test runs were conducted at the outlet exhaust stack location, with one test run being conducted per test day. Three of the MM5 samples were collected isokinetically over a 240-minute sampling period with a sample flow rate of 0.78 scfm. The fourth MM5 sample was collected isokinetically over a 172-minute period with a sample flow rate of 0.82 scfm. This test run was aborted after completing 17 of the 24 traverse points due to failure of a hydraulic oil line on the feed ram of the incinerator.

A schematic diagram of the MM5 sampling train is shown in Figure 6-3. Flue gas is pulled from the stack through a nozzle and heated glass probe. Particulate matter is removed from the gas stream by means of a fiberglass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Stack Wall
Thermocouple
Probe
Thermo-Couple
"S" Type Pitot
Cyclone
Heated Zone
Pitot Manometer
Recirculation Pump
Thermometer
Check Valve
Silica Gel
Ice Bath
Water Knockout
Impinger
Vacuum Line
Thermometers
By-Pass Valve
Orifice
Main Valve
Dry Gas Meter
Air-Tight Pump

Figure 6-3. Schematic of Modified Method 5 Sampling Train

filter housed in a teflon-sealed glass filter holder maintained at 248±25°F. The gas passes through a sorbent trap for removal of organic constituents. The trap, which is shown schematically in Figure 6-4, consists of separate sections for (1) cooling the gas stream, and (2) adsorbing the organic compounds on Amberlite XAD-2^R resin (XAD). A chilled impinger train is used to remove water from the flue gas, and a dry gas meter is used to measure the sample gas flow.

6.1.2.2 HCl Determination. HCl concentrations in the flue gas were determined using another modification of EPA Method 5. The sample train components and operation were identical to those of Method 5 with the following exceptions:

1. Water in the first two impingers was replaced with 0.1 m NaOH.
2. Sampling was two-point isokinetic with the nozzle placed at points in the stack with average velocity.
3. The moisture/NaOH in the impingers was saved for laboratory analysis by ion chromatography. The impinger catch was stored at 4°F until analysis.

One average velocity sampling point was selected for each of the two sampling ports available in the outlet exhaust stack. During the first half of the MM5 sampling period, one port was used for the HCl train, and the other port was used to traverse with the MM5 train. For the second half of the MM5 sampling period, the two trains were switched. A schematic diagram of the Method 5 train is shown in Figure 6-5.

6.1.2.3 Ambient Air Dioxin Determination. The ambient air sample was collected using the procedure outlined in the QAPP for "Combustion Air Dioxin and Precursor Determination." Dioxin in the ambient air was collected on an XAD resin trap using a sample train similar to that used for MM5.

A schematic diagram of the "ambient XAD" sample train is shown in Figure 6-6. The train consists of a probe, condenser/sorbent tube, water knockout trap, silica gel container, transfer line, pump, and dry gas meter. Ambient air is drawn into the sorbent module, where it is cooled to 68°F or lower, and the organic constituents are adsorbed by the XAD resin. The gas is then dried with the silica gel and the sample volume is measured by the

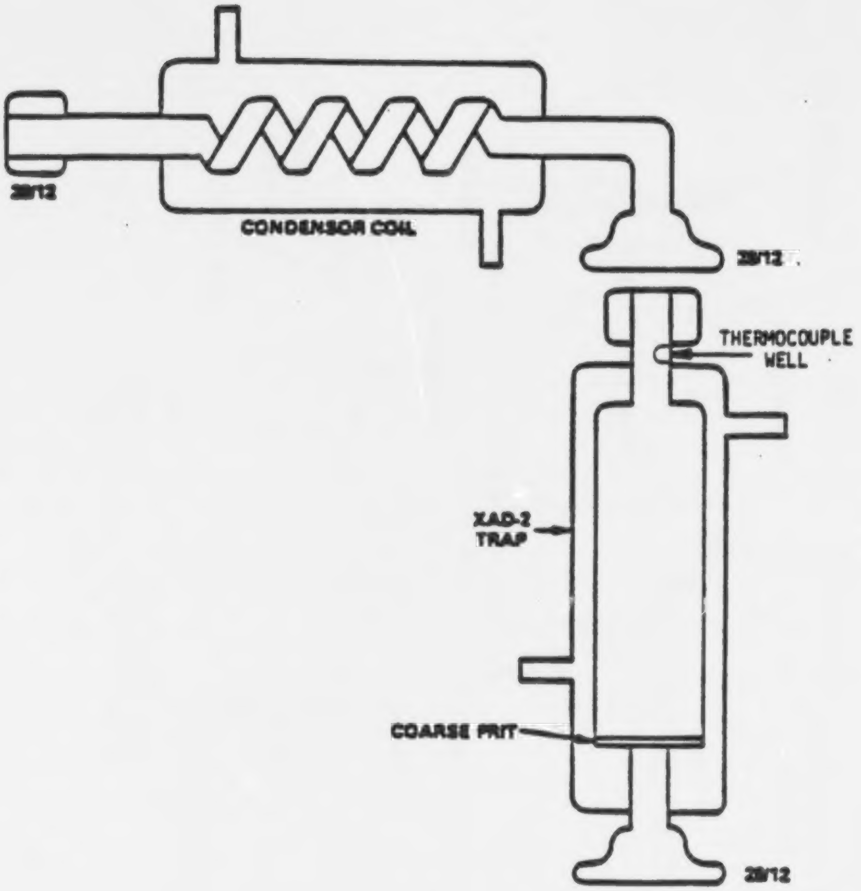
28/12
CONDENSOR COIL
28/12
THERMOCOUPLE WELL
XAD-2 TRAP
COARSE FRIT
28/12

Figure 6-4. Adsorbent sampling system.

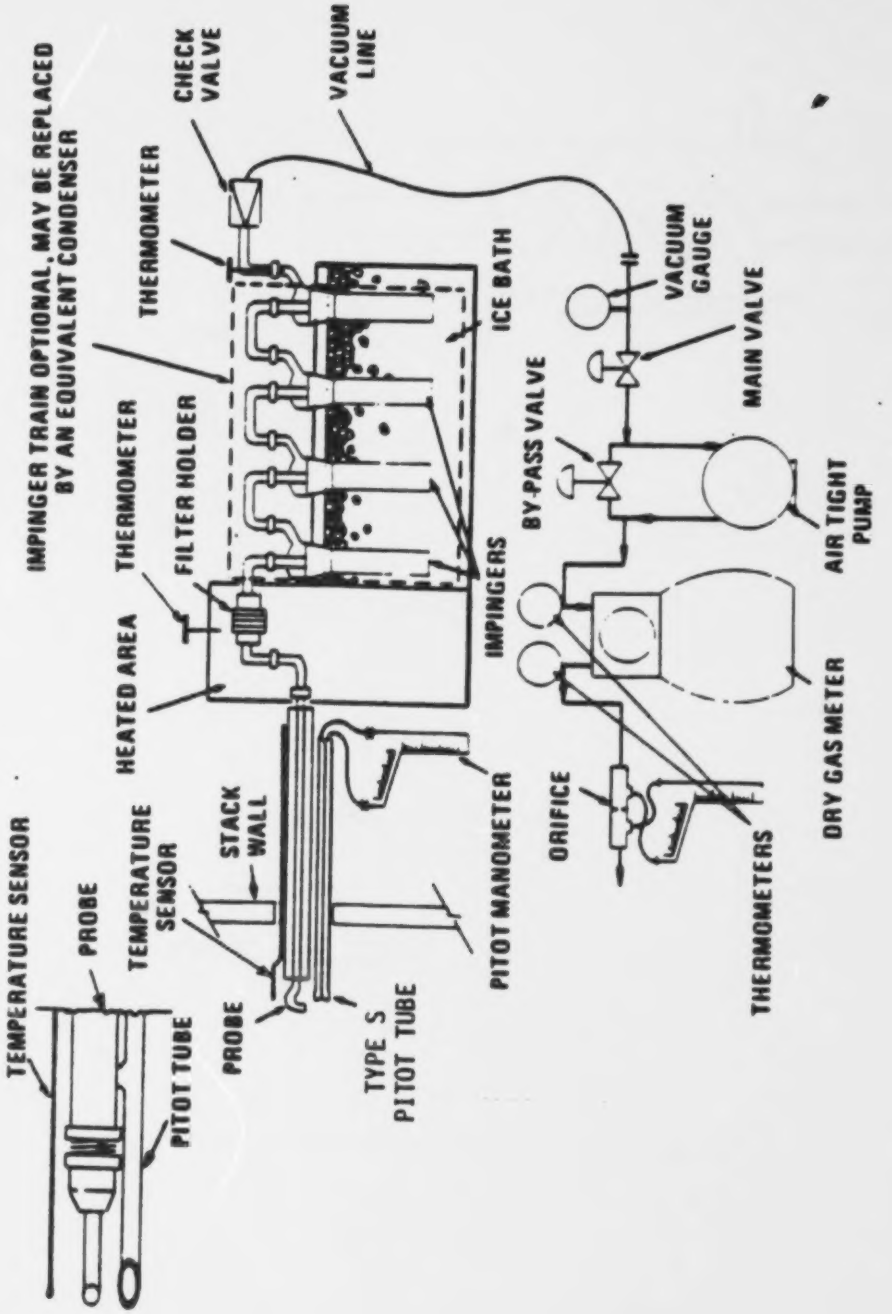
TEMPERATURE SENSOR
PROBE
PITOT TUBE
TEMPERATURE SENSOR
STACK WALL
PROBE
TYPE S PITOT TUBE
PITOT MANOMETER
HEATED AREA
THERMOMETER
FILTER HOLDER
IMPINGER TRAIN OPTIONAL, MAY BE REPLACED BY AN EQUIVALENT CONDENSER
THERMOMETER
CHECK VALVE
VACUUM LINE
ICE BATH
IMPINGERS
BY-PASS VALVE
MAIN VALVE
VACUUM GAUGE
AIR TIGHT PUMP
DRY GAS METER
ORIFICE
THERMOMETERS

Figure 6-5. Schematic of Method 5 Train

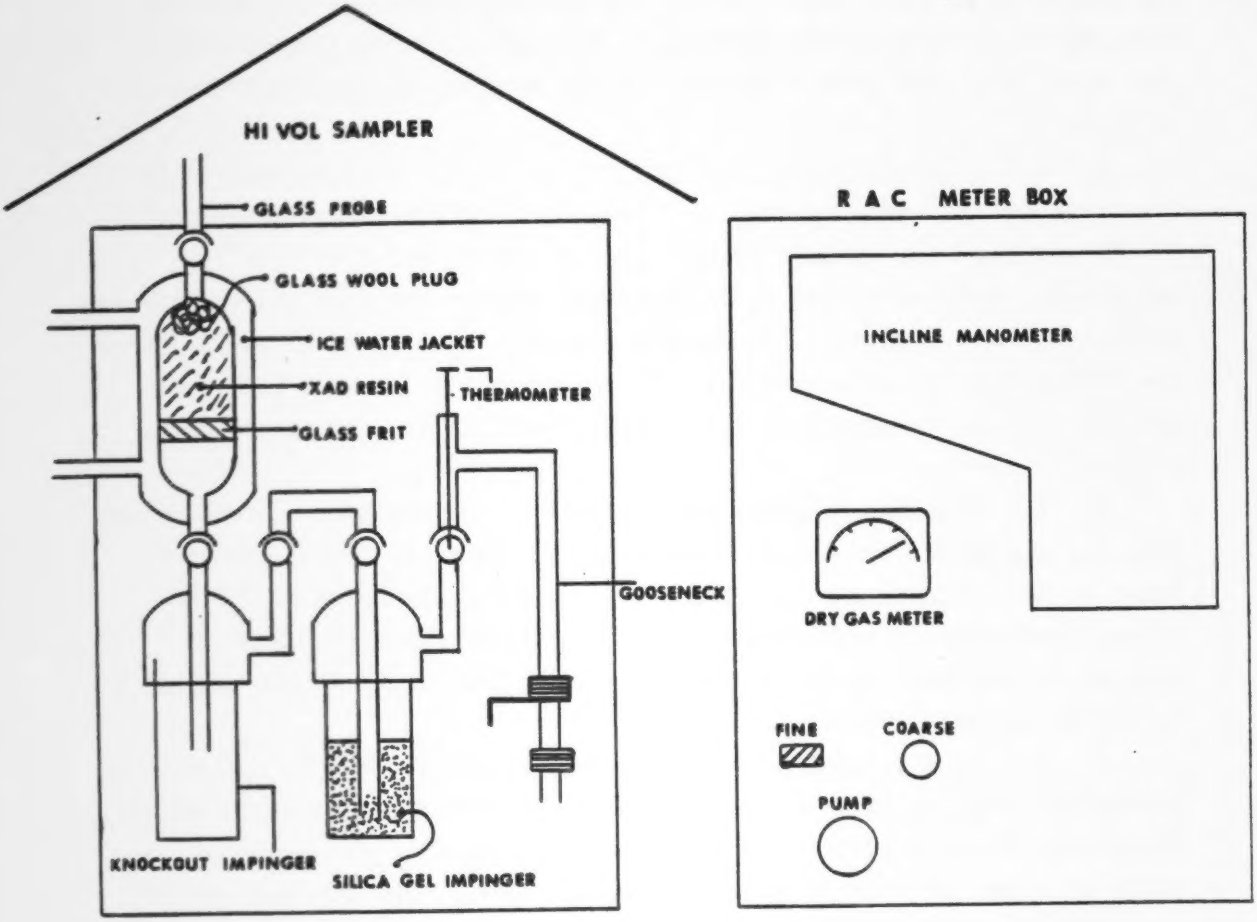
HI VOL SAMPLER
GLASS PROBE
GLASS WOOL PLUG
ICE WATER JACKET
XAD RESIN
THERMOMETER
GLASS FRIT
GOOSENECK
KNOCKOUT IMPINGER
SILICA GEL IMPINGER
R A C METER BOX
INCLINE MANOMETER
DRY GAS METER
FINE
COARSE
PUMP

Figure 6-6. Ambient XAD sample train.

dry gas meter. Recovery of the ambient XAD sample train was performed in a manner similar to that of the MM5 train. The probe was rinsed with acetone and hexane three times each. This rinse and the condensate (if any) was combined in a single sample container. The resin tube was capped with precleaned foil, and both components of the sample were sent to Troika for analysis.

6.1.2.4 Volumetric Gas Flow Rate Determination. The volumetric gas flow rate was determined during this program using procedures described in EPA Method 2. Based on this method, the volumetric gas flow rate is determined by measuring the cross-sectional area of the duct and the average velocity of the flue gas. The average flue gas velocity is calculabed from the average gas velocity pressure (P) across an S-type pitot tube, the average flue gas temperature, wet molecular weight, and the absolute static pressure.

6.1.2.5 Flue Gas Moisture Determination. The moisture content of the flue gas was determined using the methodology described in EPA Method 4. Based on this method, a known volume of particulate-free gas is pulled through a chilled impinger train. The quantity of condensed water is determined gravimetrically and then related to the volume of gas sampled to determine the moisture content.

6.1.2.6 Flue Gas Molecular Weight Determination. During testing, the integrated sampling technique described in EPA Method 3 was used to obtain integrated flue gas samples for fixed gas (O_2, CO_2, CO, N_2) analysis. A total of eight 1/2 hour integrated flue gas samples were obtained per MM5 test run. A small diaphram pump and a stainless steel probe were used to extract a single point flue gas sample which was collected in a Tedlar^R bag. Moisture was removed from the gas sample by a water-cooled condenser so that the fixed gas analysis is on a dry basis.

The composition of the gas sample was determined using a Shimadzu Model 3BT analyzer as opposed to the Fyrite or Orsat analyzer prescribed in Method 3. This instrument employs a gas chromatograph and a thermal conductivity detector to determine the fixed gas composition (CO, O_2, N_2) of the sample. Calibration of the Shimadzu analyzer was conducted according to the procedures outlined in the QAPP, which involved analysis of one or more standards of appropriate composition immediately before and after sample analysis.

6.1.2.7 Continuous Monitor. Continuous monitoring was performed at the boiler outlet sampling location for O_2, CO_2, CO, NO_x, and THC. The continuous monitoring was performed throughout the 4 to 6-hour period that dioxin sampling was being conducted each test day. The primary intent of the continuous monitoring effort was to (1) observe fluctuations in flue gas parameters, and (2) provide an indication of combustion conditions. Sample acquisition was accomplished using an in-stack filter probe and a 50 ft heat-traced Teflon® line connected to a mobile laboratory. The heat-traced line was maintained at a temperature of 149°C (300°F) to prevent condensation in the sample line. The stack gas sample was drawn through the filter and sample line using pumps located in or near the mobile laboratory. Sample gas to be analyzed for CO, CO_2, NO_x, and O_2 was then pumped through a sample gas conditioner, consisting of an ice bath and knockout trap, to remove moisture and thus provide a dry gas stream for analysis. A separate unconditioned gas slip stream was supplied to the THC analyzer for analysis on a wet basis.

An Anarad Model 412 nondispersive infrared (NDIR) analyzer was used to measure CO and CO_2; a Beckman Model 755 paramagnetic analyzer was used to measure O_2; a Teco Model 10 chemiluminescent analyzer was used to measure NO_x; and a Beckman Model 402 flame ionization analyzer was used to measure THC. Calibration of the continuous monitors was performed according to the procedures outlined in the QAPP. These procedures included a three point (two upscale plus zero) linearity check on the first test day, single point and zero point calibration checks daily, and single point drift checks at the end of each test day.

6.2 LIQUID SAMPLES

The only liquid sample collected at Site ISW-A was the No. 2 fuel oil fired in the afterburner. This sample was collected from a tap valve located in a fuel oil line leading from the fuel oil storage tank to an oil-fired boiler supplying process steam to the plant. No sample location was available in the fuel oil line leading to the incinerator. However, since the process boiler and the incinerator receive oil from the same storage tank, the tap valve used for sampling should have provided a representative sample. Grab samples of fuel oil were taken hourly during each MM5 test run. To provide a composite sample, the sample containers (amber glass jars) were graduated at increments of 1/5 of the total volume.

Samples of fuel oil were collected for dioxin/furan, precursor, and total chlorine analyses. To acquire the sample, the tap valve was fitted with an 8-inch length of 1/4-inch Teflon® tubing. The sample was collected by placing the tubing in the sample jar and opening the valve to admit a moderate flow of liquid. The conduit line was flushed before the sample was taken and covered with hexane-rinsed foil between sampling times.

6.3 SLUDGE/SOLID SAMPLES

Sludge or solid samples collected for Site ISW-A include samples of the waste feed materials, incinerator bottom ash, and soils adjacent to the plant site. Sampling locations and procedures are discussed below.

6.3.1 Waste Feed Materials Sampling

Separate feed samples were obtained for (1) paint sludge, (2) wood/plastic cutoffs, and (3) wooden crate parts, paper, and cardboard. Office and cafeteria wastes and paint filters were neither sampled nor burned during the test period.

Throughout the test period, each batch of material fed to the unit was weighed using a scale provided by the plant, and the contents of the batch were recorded. The plant reported that the scale was accurate well within ±5 percent for the range of loads weighed during the test (30 to 800 lb). The material feed rate data were used to formulate a weighed composite of the three sample types collected. Samples of waste materials were brought back to Radian's RTP laboratories and ground or reduced in size as necessary to facilitate sample extraction (see Section 7.2). A single weighed composite of the feed materials was provided to Troika for dioxin analysis. Samples to be analyzed for dioxin precursors were analyzed separately. Procedures used to collect the waste feed samples are discussed below.

6.3.1.1 Paint Sludge. As discussed in Section 3.1, paint sludge is fed to the incinerator in 5-gallon plastic buckets. Two different types of sludge, latex and "Hytest," are normally fed at a combined rate of 15 to 20 buckets per shift. An attempt was made to burn at least eight buckets of sludge during each MM5 test run, including four latex and four Hytest buckets. Samples were collected from two of the latex and two of the Hytest buckets burned. Composite samples for each type of sludge were obtained by filling sample containers (950 ml amber glass jars) halfway from one bucket and then the rest of the way from the other bucket.

6.3.1.2 Wood/Plastic Cutoffs. The wood/plastic cutoff samples were collected as sawdust in the area of the plant where window frame parts were being mitered. Dust from the mitering saws is captured by a hooding system that vents to a cyclone. The wood/plastic dust samples were collected in amber glass jars twice per test day at the outlet of the cyclone hopper. Samples of wood/plastic cutoffs as fed were also collected once per test run.

6.3.1.3 Wood, Crate Parts, Paper, and Cardboard. A composite or combined sample consisting of wood, wooden crate parts, paper, and cardboard was collected throughout each test run. Small pieces of each type of material were collected from the various batches of incinerator feed and placed in a single sample container. In collecting the sample, an effort was made to collect each of the four components of the sample in a proportion (by weight) representative of the material fed to the incinerator during the test. Duplicate samples were collected to provide one sample for dioxin/furan analysis and one sample for precursor analyses. Small pieces of different wood parts were obtained using a clean saw.

6.3.2 Bottom Ash Sampling

Bottom ash from the incinerator was conveyed to an outside storage hopper by a chain-link conveyor. Samples of the ash were collected from the storage hopper using a precleaned trowel either immediately following or during dumping of the ash. Bottom ash samples were collected once per test run.

6.3.3 Soil Sampling

The soil sample for Site ISW-A consisted of a composite of 10 samples collected near the ash handling area. Since most of the property in the vicinity of the ash handling system consisted of concrete and gravel, all 10 samples were collected from a single grassy area approximately 100 feet from the ash hoppers. A diagram of the soil sampling locations is shown in Figure 6-7. The soil samples were collected using a bulb planter which was pushed approximately 3 inches into the soil. The sample was first placed in a precleaned stainless steel bucket and then transferred with hexane-rinsed aluminum foil to amber glass sample jars.

6.4 REFERENCES

1. Palazzolo, M. A., et. al. National Dioxin Study Tier 4 - Combustion Sources Quality Assurance Project Plan. (Draft Report prepared for U.S. Environmental Protection Agency, Research Triangle Park, N.C. EPA Contract 68-03-3148, December 1984.)

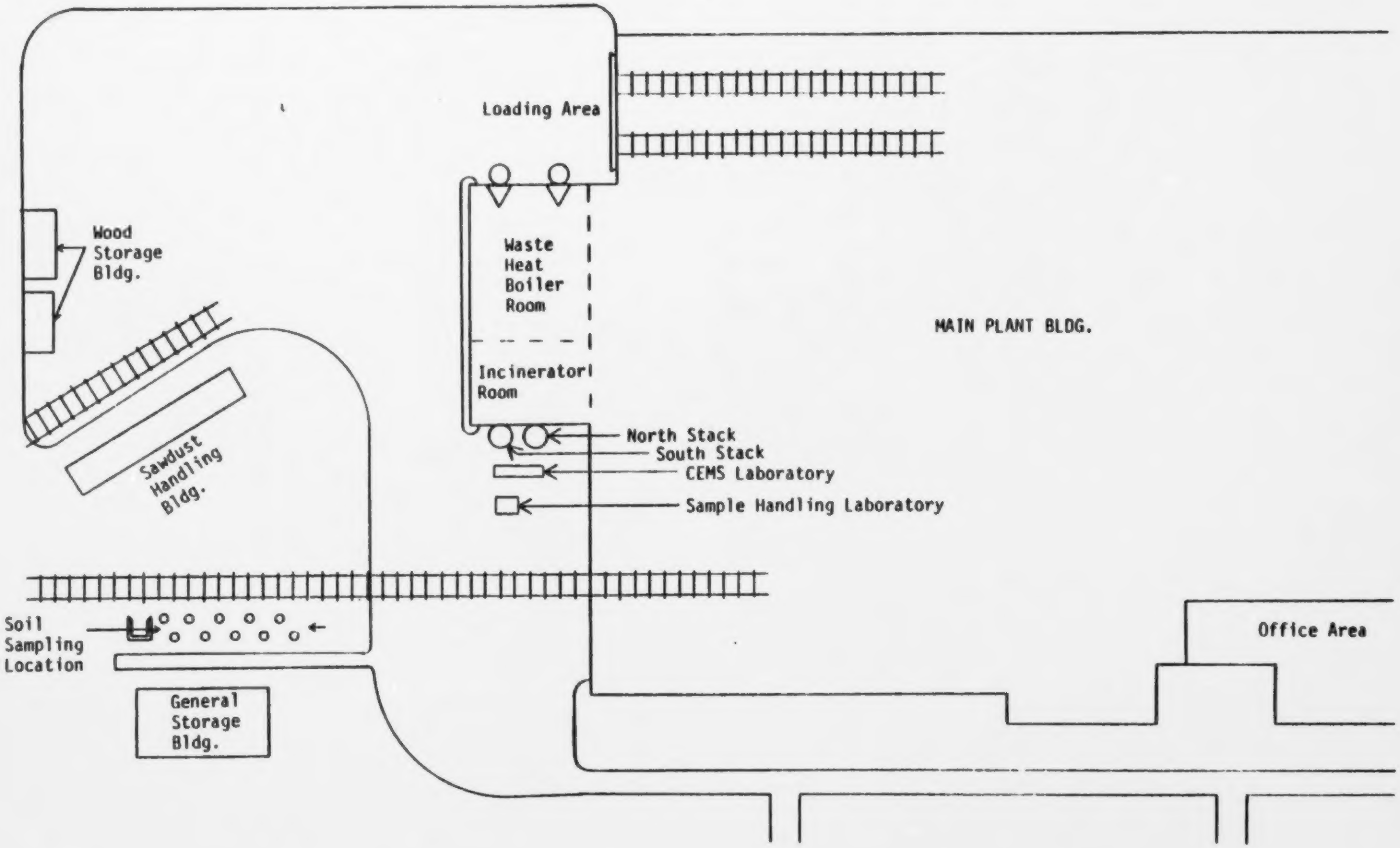
Loading Area
Wood Storage Bldg.
Waste Heat Boiler Room
MAIN PLANT BLDG.
Incinerator Room
Sawdust Handling Bldg.
North Stack
South Stack
CEMS Laboratory
Sample Handling Laboratory
Soil Sampling Location
Office Area
General Storage Bldg.

Figure 6-7. Diagram of Ash Handling and Soil Sampling Locations.

7.0 ANALYTICAL PROCEDURES

Laboratory procedures used to quantify dioxins/furans and dioxin/furan precursors in the Tier 4 samples are described in this section. MM5 train samples were analyzed by EPA's Troika laboratories for dioxin/furan content. Procedures used for these analyses are described in detail in the Analytical Procedures and QA Plan for the Analysis of Tetra- through Octa- CDD's and CDF's in Samples from Tier 4 Combustion and Incineration Processes (addendum to EPA/600/3-85-/019, April 1985). These procedures are summarized in Section 7.1.

Combustion device feed samples from Site ISW-A were analyzed by Radian to determine concentrations of chlorinated phenols (CP), chlorobenzenes (CB), polychlorinated biphenyls (PCBs), total organic halogen (TOX) and total chlorine. Procedures used for these analyses are detailed in Section 7.2.

7.1 DIOXINS/FURANS

The analytical procedures summarized in this section were used by Troika for dioxin/furan analysis of MM5 train samples from Site ISW-A. Samples consisting of organic solvents, aqueous solutions, and solids were prepared for analysis using slightly different procedures. The organic solvent samples consisted of rinses from the MM5 probe, nozzle, filter housing and condenser coil. Aqueous samples consisted of impinger catch solutions, and solid samples included filters and XAD resin. Isotopically-labeled surrogate compounds were added to all samples prior to extraction to allow determination of method efficiency and for quantification purposes.

Organic liquid samples (e.g., acetone and methylene chloride-based MM5 train rinses) were concentrated using a nitrogen blowdown apparatus. The residue, which contained particulate matter from the MM5 train probe and nozzle, was combined with the filter and handled as a solid sample. Solid samples were extracted with benzene in a Soxhlet apparatus for a period of at least 16 hours. The extract was concentrated by nitrogen blowdown and subjected to chromatographic cleanup procedures.

Aqueous solutions (e.g., MM5 train impinger samples) were extracted with hexane by vigorous shaking for a three hour period. This extraction procedure was repeated three times, with the organic fractions ultimately being combined and concentrated for chromatographic cleanup.

The cleanup procedure involved using liquid chromatographic columns to separate the compounds of interest from other compounds present in the samples. Four different types of columns were used: a combination acid and base modified silica gel column, a basic alumina column, a PX-21 carbon/celite 545 column and a silica/diol micro column. These were used in successive steps, with the last two being used only if necessary.

The cleaned samples were analyzed using high resolution gas chromatography/high resolution mass spectrometry (GC/MS). Conditions for the analyses were as follows:

Gas Chromatograph - Injector configured for capillary column, splitless injection; injector temperature 280°C; helium carrier gas at 1.2 ml/min; initial column temperature 100°C: final column temperature 240°C; interface temperature 270°C.

Mass Spectrometer - Varian/MAT Model 311A; electron energy 70ev; filament emission 1mA; mass resolution 8000 to 10,000; ion source temperature 270°C.

7.2 DIOXIN/FURAN PRECURSORS

Feed samples for Site ISW-A were analyzed by Radian/RTP for chlorophenols (CP), chlorobenzenes (CB) and polychlorinated biphenyls (PCBs) by GC/MS; total organic halides (TOX) by GC/Hall detector; total chlorine by Parr bomb combustion followed by ion chromatography. Analytical procedures are discussed in the following sections.

7.2.1 GC/MS Analyses

The analytical procedures used for determining CP, CB, and PCB concentrations in feed samples are modified versions of procedures typically used for the analysis of MM5 train components. These procedures involve initial extraction of the sample with an appropriate solvent, preliminary separation of the compounds of interest by solvent partitioning and liquid chromatography, and analysis of the processed fractions. Solutions containing CB and PCB are injected directly into the GC/MS, and solutions containing CP are derivatized prior to injection. Details on the procedures used for Site 02 samples are provided in the sections below.

7.2.1.1 Sample Preparation

A flow chart for the sample preparation procedure used for Site ISW-A feed samples is shown in Figure 7-1. The first step in the procedure involved adding labeled surrogate compounds to provide a measure of extraction method efficiency. The next step involved adding a mixture of 0.5 N NaOH and $MeCl_2$ to the sample and sonicating the sample for 30 minutes. The NaOH and $MeCl_2$ mixture converts the acid compounds to their salts and collects base/neutrals in the organic solvent. The sonicated sample was filtered and rinsed with 0.5 N NaOH. The filtrate was extracted three times in a separatory funnel with $MeCl_2$ and the aqueous and organic fractions were saved for derivatization and/or further cleanup. The aqueous fraction (or acids portion) was acidified to pH2 with HCl and then extracted three times with $MeCl_2$. The $MeCl_2$ from this extraction was dried with anhydrous Na_2SO_4, exchanged to benzene, and concentrated using a nitrogen blowdown apparatus. Acetylation of any CP present in the sample involved the following steps:

1. 2.0 mL isooctane, 2.0 mL acetonitrile, 50 uL pyridine, and 20 uL acetic anhydride were added to the extract. The test tube containing the extract was placed in a 60°C water bath for 15 minutes and was shaken 30 seconds every 2 minutes.
2. 6 mL of 0.01 N H_3PO_4 to the test tube, and the sample was agitated for 2 minutes on a wrist action shaker.

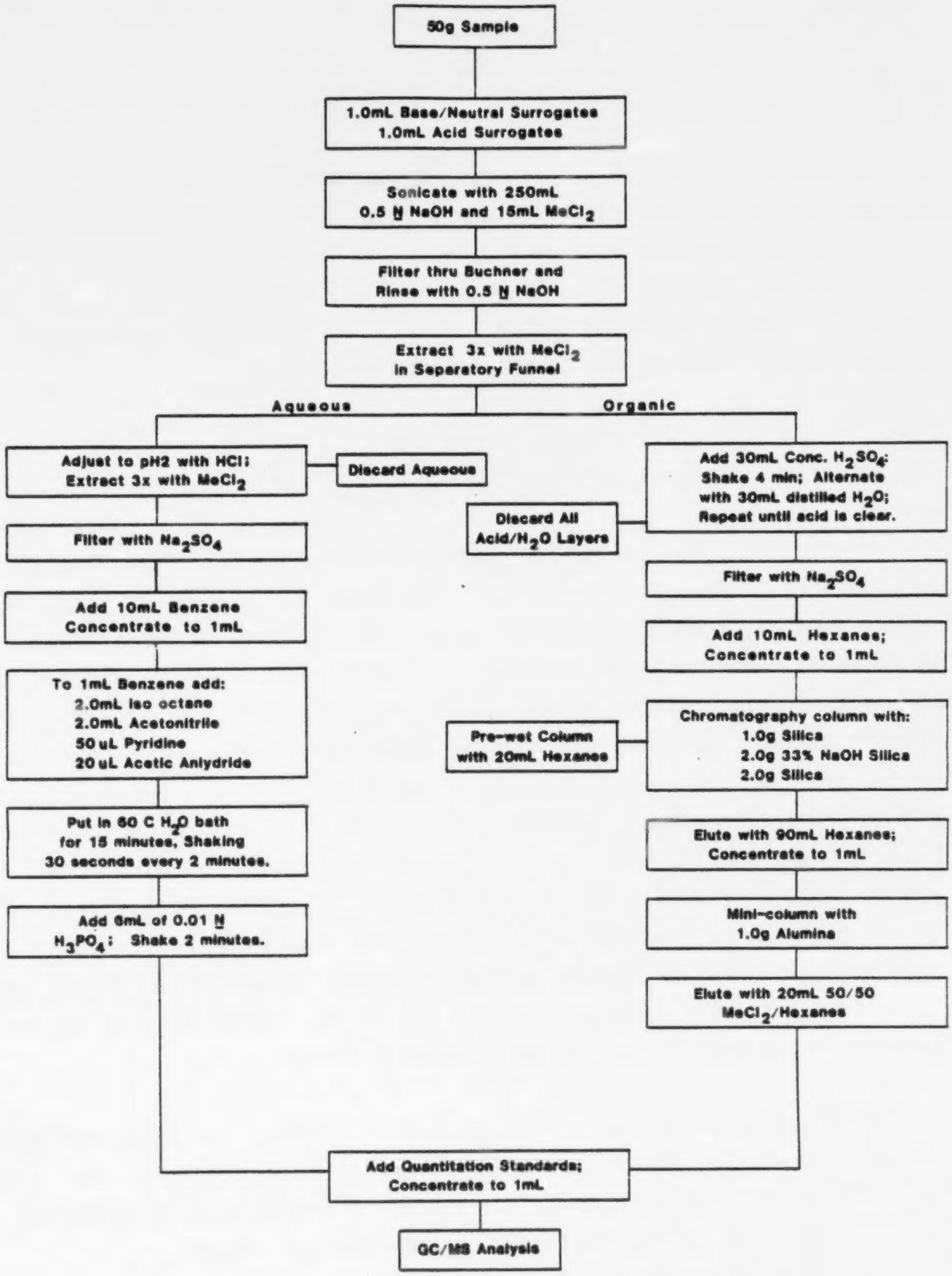
50g Sample
1.0mL Base/Neutral Surrogates 1.0mL Acid Surrogates
Sonicate with 250mL 0.5 N NaOH and 15mL MeCl$_2$
Filter thru Buchner and Rinse with 0.5 N NaOH
Extract 3x with MeCl$_2$ in Seperatory Funnel
Aqueous
Organic
Adjust to pH2 with HCl; Extract 3x with MeCl$_2$
Discard Aqueous
Filter with Na$_2$SO$_4$
Add 10mL Benzene Concentrate to 1mL
To 1mL Benzene add: 2.0mL Iso octane 2.0mL Acetonitrile 50 uL Pyridine 20 uL Acetic Anlydride
Put in 60 C H$_2$O bath for 15 minutes, Shaking 30 seconds every 2 minutes.
Add 6mL of 0.01 N H$_3$PO$_4$; Shake 2 minutes.
Add 30mL Conc. H$_2$SO$_4$; Shake 4 min; Alternate with 30mL distilled H$_2$O; Repeat until acid is clear.
Discard All Acid/H$_2$O Layers
Filter with Na$_2$SO$_4$
Add 10mL Hexanes; Concentrate to 1mL
Pre-wet Column with 20mL Hexanes
Chromatography column with: 1.0g Silica 2.0g 33% NaOH Silica 2.0g Silica
Elute with 90mL Hexanes; Concentrate to 1mL
Mini-column with 1.0g Alumina
Elute with 20mL 50/50 MeCl$_2$/Hexanes
Add Quantitation Standards; Concentrate to 1mL
GC/MS Analysis

Figure 7-1. Sample Preparation Flow Diagram for Site ISW-A Precursor Analyses

3. The organic layer was removed and the quantitation standard was added. The sample was concentrated in a Reacti-Vial at room temperature (using prepurified N_2) to 1 mL prior to GC/MS analysis.

Cleanup of the organic (or base/neutrals) layer from the first $MeCl_2$ extraction involved successively washing the extract with concentrated H_2SO_4 and deionized distilled water. The acid or water was added in a 30 mL portion and the sample was shaken for two minutes. After the aqueous (or acid) and organic layers were completely separated, the aqueous (or acid) layer was discarded. The acid washing procedure was repeated until the acid layer was colorless. The organic fraction from the final wash was dried with anhydrous Na_2SO_4, exchanged to hexane and concentrated. Final cleanup of the sample by column chromatography involved the following procedure.

A glass macro-column, 20 mm o.d. x 230 mm in length, tapered to 6 mm o.d. on one end was prepared. The column was packed with a plug of silanized glass wool, followed successively by 1.0 g silica, 2.0 g silica containing 33% (w/w) 1 N NaOH, and 2.0 g silica. After wetting the chromatography column with hexanes, the concentrated extract was quantitatively transferred to the column and eluted with 90 mL hexanes. The entire eluate was collected and concentrated to a volume of 1 mL in a centrifuge tube.

A disposable liquid chromatography mini-column was constructed by cutting off a 5-mL Pyrex disposable pipette at the 2.0 mL mark and packing the lower portion of the tube with a small plug of silanized glass wool, followed by 1 g of Woehlm basic alumina. The alumina had been previously activated for at least 16 hours at 600°C in a muffle furnace and cooled in a desiccator for 30 minutes just before use. The concentrated eluate from above was quantitatively transferred onto the liquid chromatography column. The centrifuge tube was rinsed consecutively with two 0.3-mL portions of a 3 percent $MeCl_2$: hexanes solution, and the rinses were transferred to the liquid chromatography column.

The liquid chromatography column was eluted with 20 mL of a 50 percent (v/v) $MeCl_2$:hexanes solution, and the eluate was concentrated to a volume of approximately 1 mL by heating the tubes in a water bath while passing a stream of prepurified N_2 over the solutions. The quantitation standard was added and the final volume was adjusted to 1.0 mL prior to GC/MS analysis.

7.2.1.2 Analysis

Analyses for CP, CB and PCBs present in the feed sample extracts were performed with a Finnigan Model 5100 mass spectrometer using selected ion monitoring. A fused silica capillary column was used for chromatographic separation of the compounds of interest. Analytical conditions for the GC/MS analysis are shown in Table 7-1.

Tuning of the GC/MS was performed daily as specified in the Tier 4 QA Project Plan. An internal-standard calibration procedure was used for sample quantitation. Compounds of interest were calibrated against a fixed concentration of either d_{12}-chrysene (for CB, PCB) or d_8-naphthalene (for CP). Components of the calibration solution are shown in Table 7-2. For multi-point calibrations, this solution was injected at levels of 10, 50, 100, and 150 ng/ml.

Compound identification was confirmed by comparison of chromatographic retention times and mass spectra of unknowns with retention times and mass spectra of reference compounds. Since the selected ion monitoring technique was necessary for the samples analyzed, care was taken to monitor a sufficiently wide mass region to avoid the potential for reporting false positives.

The instrument detection limit for the analytes of interest (i.e., CP, CB, and PCB) was estimated to be approximately 500 pg on column. For a 50 g sample and 100 percent recovery of the analyte, this corresponds to a feed sample detection limit of 10 ppb.

7.3 TOX ANALYSIS

Incinerator feed samples were analyzed for total organic halide (TOX) by short-column GC and a Hall detector (GC/Hall). Solid samples were extracted with benzene for at least 16 hours in a Soxhlet apparatus. The extracts were washed three times with 100 mL portions of reagent-grade water concentrated to 10 mL.

TABLE 7-1. ANALYTICAL CONDITIONS FOR THE GC/MS

Parameter	Chlorobenzenes/ Polychlorinated biphenyls	Chlorophenols
Column	30 m WB DB-5 (1.0 u film thickness) fused silica capillary	same
Injector Temperature	290°C	290°C
Separator Oven Temperature	290°C	290°C
Column Head Pressure	9 psi	9 psi
He flow rate	1 mL/min	1 mL/min
GC program	40(4)-290°C, 10°/ min & hold	40(1)-290°C, 12°/min & hold
Emission Current	0.50 mA	0.50 mA
Electron Energy	70 eV	70 eV
Injection Mode	Splitless 0.6 min, then 10:1 split	
Mode	Electron ionization, Selected Ion Monitoring	

TABLE 7-2. COMPONENTS OF THE CALIBRATION SOLUTION

Base/Neutrals	Acids
4-chlorobiphenyl	2,5-dichlorophenol
3,3'-dichlorobiphenyl	2,3-dichlorophenol
2,4',5-trichlorobiphenyl	2,6-dichlorophenol
3,3'4,4'-tetrachlorobiphenyl	3,5-dichlorophenol
2,2',6,6'-tetrachlorobiphenyl	3,4-dichlorophenol
2,2,4,5,6-pentachlorobiphenyl	2,3,5-trichlorophenol
2,2',4,4',5,5'-hexachlorobiphenyl	2,3,6-trichlorophenol
2,2',3,4,4',5',6-heptachlorobiphenyl	3,4,5-trichlorophenol
2,2',3,3',4,4',5,5'-octachlorobiphenyl	2,4,5-trichlorophenol
2,2',3,3',4,4',5,6,6'-nonachlorobiphenyl	2,3,4-trichlorophenol
decachlorobiphenyl	2,3,5,6-tetrachlorophenol
p-dichlorobenzene	pentachlorophenol
1,2,4-trichlorobenzene	d_6-phenol (SS)
1,2,3,5-tetrachlorobenzene	d_4-2-chlorophenol (SS)
pentachlorobenzene	$^{13}C_6$-pentachlorophenol (SS)
hexachlorobenzene	d_8-naphthalene (QS)
d_4-1,4-dichlorobenzene (SS)[1]	2,4,6-tribromophenol (QS)
3-bromobiphenyl (SS)	d_{10}-phenanthrene (QS)
2,2'.5,5'-tetrabromobiphenyl (SS)	d_{12}chrysene (QS)
2,2',4,4',6,6'-hexabromobiphenyl (SS)	
octachloronaphthalene (QS)[2]	
d_{10}-phenanthrene (QS)	
d_{12}-chrysene (QS)	

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[1] Surrogate standard.

[2] Quantitation standard.

An attempt to use a fused silica capillary column to separate surrogates from target compounds was unsuccessful due to the complexity of the sample constituents. Determinations for TOX were therefore performed on samples without surrogates and no measure of extraction efficiency is available.

Instrument conditions are shown in Table 7-3. Sample quantitation was based on an average response factor developed from a mixture of chlorinated benzenes and brominated biphenyls. Individual CP, CB and PCBs were also injected at various concentrations to develop a calibration curve for comparison to the mixture response factors.

7.4 TOTAL CHLORINE ANALYSIS

Total chlorine concentrations in feed samples were determined by Parr bomb combustion followed by ion chromatography (IC). A 0.5g sample was placed in the Parr bomb with 10 mL of a 50 g/L Na_2CO_3 solution. After combustion of the samples according to standard procedures (ASTM 2015), the contents of the bomb were rinsed into a 100 mL flask and diluted to 100 mL. The resulting solution was analyzed for chloride concentration (Cl^-) by IC using standard anion conditions. For samples difficult to combust (such as sludges), 25 drops of paraffin oils were added to the bomb prior to combustion.

TABLE 7-3. ANALYTICAL CONDITIONS FOR TOX ANALYSIS

Hall Detector Conditions

Reactor temperature - 850°C
Solvent - n-propanol
Hydrogen flow rate - 35 mL/min

GC Conditions (Varian 3700)

Injection volume (1 - 5 uL)
Helium carrier gas flow rate - 60 mL/min
Column - 3-ft packed column with 1 in 10% OV 101
Column temperature - 200°C isothermal

8.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

This section summarizes results of the quality assurance and quality control (QA/QC) activities for field sampling and laboratory analyses for Site ISW-A. The flue gas and bottopm ash dioxin/furan data for Site ISW-A were within the QC specifications outlined in the Tier 4 QAPP. Surrogate recoveries for all the samples were within the specified limits of 50 to 120 percent for labeled TCDD's and 40 to 120 percent for hepta- and octa-CDD's. The results of the analysis of the fortified laboratory QC sample were within 33 percent for all homologues except octa-CDF. Recovery for octa-CDF was 59 percent, which is just outside the accuracy objective of 60 to 140 percent. Overall the dioxin/furan analysis gave reasonable results.

The dioxin/furan precursor analysis of the feed samples was not as accurate as the dioxin/furan homologue analysis. In general, the surrogate recoveries were outside the specified QC limits of 100 ± 50 percent for all types of feed samples. The low precursor surrogate recoveries resulted from two difficulties encountered during analysis. Initially, due to the complex nature of the feed samples extensive clean-up procedures were necessary, which increased the potential for losses during sample preparation. Secondly, larger sample sizes were necessary to ensure representative samples; however, the amount of labeled surrogate was not increased in proportion to sample size. In spite of the relatively low surrogate recovery values, the resulting analytical sensitivity for the target analytes was considered acceptable or the purpose of this study.

The following sections summarize the results of all Site ISW-A QA/QC activities. Manual gas sampling methods are considered in Section 8.1 and continuous monitoring and molecular weight determinations are considered in Section 8.2. The laboratory analysis QA/QC activities are summarized in Section 8.3.

8.1 MANUAL GAS SAMPLING

Manual gas sampling methods used at Site ISW-A included modified Method 5 (MM5), the HCl acid train, EPA Methods 1 through 4, and the ambient air/XAD train. These methods are discussed in Section 6.0. Quality assurance and quality control (QA/QC) activities for the manual methods centered around 1) equipment calibration, 2) glassware precleaning, 3) procedural QC checks and 4) sample custody procedures. Key activities and QC results in each of these areas are discussed in this section. Also discussed are problems encountered that may have affected data quality.

Pretest calibrations or inspections were conducted on pitot tubes, sampling nozzles, temperature sensors and analytical balances. Both pre and post-test calibrations were also performed on dry gas meters. All of this equipment met the calibration criteria specified in the QAPP. Differences in pre- and post-test dry gas meter calibrations were less than 3.4 percent.

An extensive precleaning procedure was implemented for all sample train glassware and sample containers. This cleaning procedure, which is outlined in Table 8-1, was implemented to minimize the potential for sample contamination with substances that may have interfered with the analysis for dioxins and furans. To minimize the potential for contamination in the field, all sample train glassware was kept capped until use and a dust free environment was maintained for train assembly and sample recovery.

Procedural QC activities during manual gas sampling focused on:

- inspecting equipment visually,
- collecting sample train blanks,
- ensuring the proper location and number of traverse points,
- conducting pre-test, port change and post-test sample train leak checks,
- maintaining proper temperatures at the filter housing, sorbent trap and impinger train,
- maintaining isokinetic sampling rates, and
- recording all data on preformatted data sheets.

Results of isokinetic calculations for the MM5 and HCl test runs are shown with EPA Method 4 results in Table 8-2. As shown in Table 8-2, the average isokinetic sampling rate for both the MM5 and HCl sampling trains exceeded the QA objective of ±10 percent for test runs 3 and 4. The slightly

TABLE 8-1. GLASSWARE PRECLEANING PROCEDURE

NOTE: USE DISPOSABLE GLOVES AND ADEQUATE VENTILATION

1. Soak all glassware in hot soapy water (Alconox) 50°C or higher.
2. H_2O rinse (X3)[a].
3. Distilled/deionized H_2O rinse (X3).
4. Chromerge rinse, if glass, otherwise skip to 6.
5. High purity liquid chromatography grade H_2O rinse (X3).
6. Acetone rinse (X3), (pesticide grade).
7. Hexane rinse (X3), (pesticide grade).
8. Oven dry (110°C - 2 hrs).
9. Cap glassware with clean glass plugs or hexane rinsed aluminum foil.

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[a] (X3) = three times.

TABLE 8-2. RESULTS OF ISOKINETIC CALCULATIONS AND MOISTURE DETERMINATIONS

Run Number	Modified Method 5 Isokinetics[a] (%)	Modified Method 5 Moisture (%)	HCl Acid Train Isokinetics[a] (%)	HCl Acid Train Moisture (%)
1	104	7.45	102	6.18
2	104	7.62	101	5.51
3	112	8.44	112	8.20
4	111	7.73	118	7.39

[a] QA objective for isokinetics was 100±10 percent.

high isokinetics for these test runs is not expected to have a significant impact on the dioxin/furan or HCl emission determinations for these test runs. The high isokinetics sampling rate would effect only the quantity of particulate matter collected on the filter. The dioxins/furans (or HCl) of greatest interest are expected to be in the vapor phase and the quantity collected in the sample train would not be effected by isokineticity.

In considering the isokineticity of samples collected from Site ISW-A, it should also be noted that large fluctuations in stack gas temperature and velocity occurred periodically throughout all of the MM5 and HCl test runs. As discussed in Section 3.0, the induced draft fan downstream of the waste heat boiler on the incinerator cycled on and off to meet steam demands of the plant. During periods when the fan cycled, stack gas temperatures varied from about 300°F when the fan was on to as high as 700 or 800°F when the fan was off. Corresponding changes in stack gas velocity occurred with these changes in temperature. Since periods when the fan was off rarely exceeded 30 seconds, the MM5 or HCl sampling rate could not be adjusted to account for these periods. Sampling rate adjustments were, therefore, based only on the instantaneous stack temperature and pitot tube readings taken at set five-minute intervals.

Limited data collected during one test run show that the fan operated 71 minutes during a 74-minute period of observation with the fan cycling off and on 10 times. However, since a number of plant operating conditions affect steam demand from the waste heat boiler, the period of time that the fan actually operated during a given test run is unknown.

Initial, final and port change leak checks for the MM5 trains were passed for all of the test runs. However, the glass probes on the HCl trains were found to be broken at the end of test runs 2 and 3. The cause of the breakage was apparently a tight probe-cyclone bypass-filter holder assembly. The actual time that the breakage occurred during the sampling run is not known, but the breakage is most likely to have occurred either during the port change or when the train was removed from the stack for disassembly. Following a review of the chloride analysis results, the HCl data for Run 2 was invalidated because the HCl values determined for this run were unreasonably low compared to those for Runs 1 and 4. Results for Run 3 were very similar to those for Runs 1 and 4 and it appears likely that this probe was not broken until after sampling was completed.

Sample custody procedures used during this program emphasized careful documentation of the sample collected and the use of chain-of-custody records for samples to be transported. Steps taken to identify and document samples collected included labeling each sample with a unique alphanumeric code and logging the sample in a master sample logbook. All samples shipped to Troika or returned to Radian were also logged on chain-of-custody records that were signed by the sampler at shipment and then by the receiving laboratory when the samples arrived. Each sample container was also sealed with a chain-of-custody seal so that the container could not be opened without tearing the seal.

8.2 CONTINUOUS MONITORING/MOLECULAR WEIGHT DETERMINATION

Flue gas parameters monitored continuously during the MM5 test runs included CO, CO_2, O_2, total hydrocarbons (THC), and NO_x. Concentrations of CO_2, O_2, and N_2 were also determined for integrated bag samples of stack gas. Quality control results for these analyses are discussed in this section.

Drift check and quality control standard analysis results for the continuously monitored flue gas parameters are summarized in Table 8-3. The acceptance criterion for drift checks was an instrument drift within ± 10 percent. All data reduction was performed by assuming a linear drift of instrument response over the test day. The largest calibration drifts were observed for CO and CO_2, both of which exceeded acceptance criterion for three of the four test runs. The instrument showing the smallest drift was the O_2 monitor.

The quality control standards for this program consisted of mid-range standards that were not used for instrument calibration but were analyzed immediately after calibration to provide data on day-to-day instrument variability. The acceptance criterion for each control standards was agreement within ± 10 percent of the running mean value. All of the instruments met this criterion on each test day except for the CO monitor. However, failure of the CO monitor to meet the acceptance criterion during

Test Date	Test Run	Parameter	Drift Check			QC Standard			
			Input Concentration	Instrument Drift, %[a]	Meets QC?[b]	Input Concentration	Output Concentration	Difference From Running Mean, %	Meets QC?[c]
11/7/84	01	O_2	21.2%	0.85	Yes	9.55%	9.27%	2.2	Yes
11/8/84	02	O_2	21.2%	- 1.03	Yes	9.55%	10.0%	3.8	Yes
11/9/84	03	O_2	21.2%	- 0.44	Yes	9.55%	9.48%	1.5	Yes
11/12/84	04	O_2	21.2%	- 0.22	Yes	9.55%	9.51%	0.94	Yes
11/7/84	01	CO	5430 ppmv	5.61	Yes	2060 ppmv	2503 ppmv	9.7	Yes
11/8/84	02	CO	520 ppmv	-28.5	No	2060 ppmv	1865 ppmv	13.0[d]	No
11/9/84	03	CO	520 ppmv	32.8	No	2060 ppmv	2299	5.4[d]	Yes
11/12/84	04	CO	520 ppmv	-11.5	No	2060 ppmv	1660	20.1[d]	No
11/7/84	01	CO_2	17.6%	19.1	No	12.8%	13.1	0.8	Yes
11/8/84	02	CO_2	17.6%	6.6	Yes	12.8%	14.0	5.0	Yes
11/9/84	03	CO_2	17.6%	21.5	No	12.8%	12.5	4.7	Yes
11/12/84	04	CO_2	17.6%	10.6	No	12.8%	13.4	1.8	Yes
11/7/84	01	NO_x	153 ppmv	3.9	Yes	84.6 ppmv	85.9	0.4	Yes
11/8/84	02	NO_x	153 ppmv	2.7	Yes	84.6	88.2	1.5	Yes
11/9/84	03	NO_x	153 ppmv	10.3	No	84.6	86.3	0.5	Yes
11/12/84	04	NO_x	153 ppmv	9.2	Yes	84.6	80.6	5.8	Yes
11/7/84	01	THC	90 ppmv	NA[e]	NA	60.3 ppmv	NA	NA	NA
11/8/84	02	THC	90 ppmv	20.8	No	60.3 ppmv	56.4	0.0	Yes
11/9/84	03	THC	90 ppmv	7.5	Yes	60.3 ppmv	59.7	2.8	Yes
11/12/84	04	THC	90 ppmv	4.0	Yes	60.3 ppmv	60.1	2.3	Yes

[a] Instrument drift is defined as the percent difference between the instrument response to the input concentration at the beginning and end of the test run.

[b] QC criteria was instrument drift within ±10 percent.

[c] QC criteria was output concentration within ±10 percent of the running mean concentration for this test site.

[d] Input QC concentration exceeded instrument span of 0 to 520 ppmv on these test days.

[e] Not available due to instrument malfunction.

test runs 2, 3, and 4 is not entirely unexpected. The QC standard (2060 ppmv) was above the calibration range selected for the CO instrument during these test runs (0 to 520 ppmv) and, the CO instrument shows some non-linearity at low concentration. The instrument was calibrated at a low range to maximize instrument accuracy near the CO levels present in the flue gas.

Molecular weight was determined by analyzing integrated bag samples of stack gas for CO_2, O_2, and N_2. Quality control for this analysis involved duplicate analyses of calibration gases immediately before and after sample analysis. Analysis of the calibration gases was to be repeated until two consecutive analyses within ±5 percent were obtained. This same criterion of ±5 percent also applied to duplicate analyses required for each sample quantitation. These criteria were met for all molecular weight determinations.

8.3 LABORATORY ANALYSES

QA/QC data collected for the various laboratory analyses performed on Site 02 samples are discussed in this section. Dioxin/furan QC data are discussed in Section 8.3.1, precursor QC data are discussed in Section 8.3.2, and total chloride and organic halide data are summarized in Section 8.3.3.

8.3.1 Dioxin/Furan QC Data

Surrogate recoveries for dioxin/furan analyses performed on Site ISW-A samples are presented in Table 8-4. All of the surrogate recoveries are within the target ranges of 50 to 120 percent for the labeled TCDD's and 40 to 120 percent for the labeled hepta- and octa-CDD's.

Results for dioxin/furan blank samples and a QC (fortified spiked) sample are summarized in Table 8-5. Again surrogate recoveries were all within the target ranges. The field blank and the laboratory blank were found to be clean with the exception of 2.9 ng of octa-CDD and 0.2 ng of other TCDF in the field blank. Comparison of measured and spiked quantities for the QC sample shows excellent recoveries for the unlabeled PCDD and PCDF, with the exception of the octa-CDF. Recovery for octa-CDF was 59 percent, which is just outside the accuracy objective of 60 to 140 percent for this sample.

TABLE 8-4. SUMMARY OF SURROGATE RECOVERIES FOR DIOXIN/FURAN ANALYSES ON SITE ISW-A SAMPLES

Compound	Surrogate Recoveries (percent)						
	Run 1 MM5	Run 2 MM5	Run 3 MM5	Run 4 MM5	Run 1 Ash[a]	Run 3 Ash[a]	Run 4 Ash[a]
$^{37}Cl_4$-TCDD	96	94	96	102	--	--	--
$^{13}C_{12}$-TCDD	98	92	88	82	99	100	94
$^{37}Cl_4$-Hepta-CDD	88	81	98	86	--	--	--
$^{13}C_{12}$-Octa-CDD	73	68	54	41	43	56	69

[a] Only two surrogates were used in the bottom ash samples analysis.

TABLE 8-5. SUMMARY OF RESULTS FOR DIOXIN/FURAN BLANK SAMPLES AND FORTIFIED QC SAMPLES

Compound	Field Blank	Laboratory Blank	Fortified QC Sample
	Surrogate Recoveries, Percent		
$^{37}Cl_4$-TCDD[a]	96	96	102
$^{13}C_{12}$-TCDD[a]	86	110	108
$^{37}Cl_4$ Hepta-CDD[b]	79	57	64
$^{13}C_{12}$ Octa-CDD[b]	60	56	57
	Amount detected, ng (Amount spiked on fortified sample, ng)		
Dioxins			
2378 TCDD	ND[c]	ND	0.4 (0.4)
Other TCDD	ND	ND	ND (0)
Penta CDD	ND	ND	ND (0)
Hexa CDD	ND	ND	1.6 (1.6)
Hepta CDD	ND	ND	2.6 (2.4)
Octa CDD	2.9	ND	3.3 (3.2)
Furans			
2378 TCDF	ND	ND	0.3 (0.4)
Other TCDF	0.2	ND	ND (0)
Penta CDF	ND	ND	0.7 (0.8)
Hexa CDF	ND	ND	1.7 (1.6)
Hepta CDF	ND	ND	2.3 (2.4)
Octa CDF	ND	ND	1.9 (3.2)

[a] Spiked at 5 ng in each sample.

[b] Spiked at 20 ng in each sample.

[c] ND = not detected. Detection limit ranged from 0.01 to 0.19 ng.

8.3.2 Precursor QC Data

Surrogate recovery efficiencies for six labeled compounds spiked into incinerator feed samples are presented in Table 8-6. The recoveries vary considerably depending on sample type and the particular surrogate. Recoveries for wood/plastic cutoffs ranged from 0 to 46 percent. Cardboard/paper/wood ranged from 0 to 362 percent and paint sludges ranged from 0 to 75 percent. With the exception of bromobiphenyl in one cardboard/paper/wood sample, the surrogate recoveries are generally below the 50 percent objective stated in the Tier 4 QA Project Plan and are below those generally considered achievable when analyzing for similar compounds in water or from MM5 train components. There are no directly comparable surrogate recovery values reported in the literature for samples similar to those analyzed for Site ISW-A. The high recovery for bromobiphenyl in the one sample may be due to native compound present in the sample.

There are several reasons for the comparatively low precursor surrogate recoveries reported in the Tier 4 study for samples such as Site ISW-A feed samples. First, the complex nature of the samples required extensive clean-up procedures prior to GC/MS analysis, which increased the potential for losses of the surrogate compounds (and analytes) during sample preparation. Second, large sample sizes (25 to 50 g) were required to increase method sensitivity for the target analytes and to ensure that representative portions of the samples were analyzed. Due to the high cost of labeled surrogates, it was not desirable to spike the large sample sizes with surrogates in proportion to that normally used for smaller samples. Supplemental in-house laboratory studies showed that when sample size was restricted to 1 g and the amount of surrogate spiked was held fixed, surrogate recoveries improved and were directly comparable to those obtained by Tiernan and co-workers for municipal incinerator feed materials. Surrogate recoveries for Tier 4 samples and the results for small sample sizes are further discussed in the Tier 4 Engineering Analysis Report.

In spite of the relatively low surrogate recovery values for some of the feed samples, the resulting analytical sensitivity for the target analytes was considered acceptable for the purpose of this study. The instrumental

TABLE 8-6. SUMMARY OF SURROGATE RECOVERIES FOR DIOXIN PRECURSOR ANALYSES

		Precursor Surrogate Recoveries (percent)[a]			
Sample Type		Wood/ Plastic Cutoff	Cardboard/ Paper/ Wood	Hytest Paint Sludge	Latex Paint Sludge
Test Run	Compound				
2	d_4-Dichlorobenzene	13	65	ND	ND
	Bromobiphenyl	19	362	2	8
	Tetrabromobiphenyl	22	78	ND	ND
	d_6 - Phenol	18	14	27	23
	d_4 - Chlorophenol	30	22	9	27
	$^{13}C_6$ - Pentachlorophenol	36	20	ND	23
3	d_4-Dichlorobenzene	ND	-	ND	ND
	Bromobiphenyl	ND	-	ND	1
	Tetrabromobiphenyl	ND	-	ND	ND
	d_6 - Phenol	5	-	11	47
	d_4 - Chlorophenol	6	-	12	37
	$^{13}C_6$ - Pentachlorophenol	46	-	6	31
4	d_4-Dichlorobenzene	ND	6	ND	ND
	Bromobiphenyl	ND	20	3	ND
	Tetrabromobiphenyl	ND	14	ND	ND
	d_6 - Phenol	5	6	120	75
	d_4 - Chlorophenol	9	10	23	ND
	$^{13}C_6$ - Pentachlorophenol	25	3	14	8

[a] Surrogates spiked at 200 ng each in 50 g sample.

detection limit ranged from about 100 to 500 picograms on-column for the 1 microliter of final extract injected into the GC/MS. At a method recovery efficiency of 100 percent for a 50 gram solid sample cleaned up to a final extract volume of 1 milliliter, the overall analytical sensitivity would be approximately 2 to 10 ppb in the solid sample. For samples such as the paint sludge with surrogate recoveries as low as 1 percent, the overall analytical sensitivity of the method would still be 200 to 1000 ppb, or 0.2 to 1.0 ppm. Thus, even in a worst-case situation the analytical procedures used provide information on the precursor content of the feed samples down to the ppm level.

A single matrix spike was analyzed for the Site ISW-A feed samples. This sample showed 6 to 9 percent recovery for spiked chlorobenzenes and 8 to 11 percent for spiked chlorinated biphenyls in a wood/plastic cutoff sample. Chlorinated phenols were not spiked in this sample. Results of laboratory blanks for the precursor analyses all showed no detectable levels of the target compounds.

8.3.3 Chloride and Organic Halide QC Data

Chloride analyses were performed by Radian laboratories on HCl acid train samples. Results for two audit samples submitted with the HCl train samples showed -3.6 percent error at 27.6 mg/L chloride and 13 percent error at 8.1 mg/L. These results are considered acceptable, although one of the errors exceeds the 7 percent accuracy objective in the Tier 4 QA plan.

Total chloride analyses were performed by Research Triangle Institute on one composite feed sample and three fuel oil samples. Blank analysis values obtained for the Parr bomb combustion/ion chromatography technique were 36, 0, 56, and 18 ppm chloride. Data presented in Section 5 were blank corrected. A LECO coal sample containing 2600 ppm chloride was analyzed as a daily QC standard. Reported values were 2500, 2500, 2500, and 2400 ppm.

Quality control for the total organic halide (TOX) data consisted of a single QC sample analysis. The sample contained 2-chlorophenol and pentachlorophenol at a TOX level of 376 ppm. The total TOX measured for the sample was 251 ppm, showing 67 percent recovery.

APPENDIX A
FIELD RESULTS

APPENDIX A-1
MODIFIED METHOD 5 and
EPA METHODS 1-4 FIELD RESULTS

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```
      RADIAN  SOURCE  TEST
      EPA  METHOD  2-5
      (RAW  DATA)
    PLANT                  : DIOXIN SITE #02
    PLANT SITE             :
    SAMPLING LOCATION      :
INCINERATOR (NORTH UNIT) EXHAUST
    TEST #                 : 02-MM5-01
    DATE                   : 11/07/84
    TEST PERIOD            : 1047-1545  (1047-1247 / 1345-1545)

   PARAMETER                                    VALUE
   ---------                                    -----

   Sampling time (min.)                          240
   Barometric Pressure (in.Hg)                   29.19
   Sampling nozzle diameter (in.)                .302
   Meter Volume (cu.ft.)                         181.776
   Meter Pressure (in.H2O)                       1.937708
   Meter Temperature (F)                         87.4
   Stack dimension (sq.in.)                      962.115
   Stack Static Pressure (in.H2O)               -.38
   Stack Moisture Collected (gm)                 292.7
   Absolute stack pressure(in Hg)                29.16206
   Average stack temperature (F)                 286.7917
   Percent CO2                                   4.84
   Percent O2                                    17.58
   Percent N2                                    77.58
   Delps Subroutine result                       13.87255
   DGM Factor                                    .9973
   Pitot Constant                                .84
```

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```
        RADIAN  SOURCE  TEST
        EPA  METHODS  2-5
        FINAL  RESULTS
      PLANT                   : DIOXIN SITE #02
      PLANT SITE              :
      SAMPLING LOCATION       :
  INCINERATOR (NORTH UNIT) EXHAUST
      TEST #                  : 02-MM5-01
      DATE                    : 11/07/84
      TEST PERIOD             : 1047-1545  (1047-1247 / 1345-1545)

        PARAMETER                    RESULT
        ---------                    ------

        Vm(dscf)                      171.4268
        Vm(dscm)                      4.854806
        Vw gas(scf)                   13.80081
        Vw gas (scm)                  .3908388
        % moisture                    7.45073
        Md                            .9254927
        MWd                           29.4776
        MW                            28.62244
        Vs(fpm)                       2068.901
        Vs (mpm)                      630.7626
        Flow(acfm)                    13823.06
        Flow(acmm)                    391.4691
        Flow(dscfm)                   8815.934
        Flow(dscmm)                   249.6672
        % I                           104.0099
        % EA                          605.9727




                                          Program Revision:1/16/84
```

```
                RADIAN SOURCE TEST
                EPA METHOD 2-5
                 (RAW DATA)
             PLANT                  : DIOXIN SITE #02
             PLANT SITE             :
             SAMPLING LOCATION      :
         INCINERATOR (NORTH UNIT) EXHAUST
             TEST #                 : 02-MM5-02
             DATE                   : 11/8/84
             TEST PERIOD            :
-2023 (1255-1345/1503-1613/1905-1917/1940-2023)


           PARAMETER                                   VALUE
           ---------                                   -----

           Sampling time (min.)                         172
           Barometric Pressure (in.Hg)                  29.25
           Sampling nozzle diameter (in.)               .309
           Meter Volume (cu.ft.)                        139.8991
           Meter Pressure (in.H2O)                      2.323889
           Meter Temperature (F)                        93.06944
           Stack dimension (sq.in.)                     962.115
           Stack Static Pressure (in.H2O)              -.38
           Stack Moisture Collected (gm)                229
           Absolute stack pressure(in Hg)               29.22206
           Average stack temperature (F)                316.7222
           Percent CO2                                  3.84
           Percent O2                                   18.19
           Percent N2                                   77.97
           Delps Subroutine result                      15.37734
           DGM Factor                                   .9973
           Pitot Constant                               .84
```

```
          RADIAN SOURCE TEST
          EPA METHODS 2-5
          FINAL RESULTS
      PLANT                 : DIOXIN SITE #02
      PLANT SITE            :
      SAMPLING LOCATION     :
  INCINERATOR (NORTH UNIT) EXHAUST
      TEST #                : 02-MM5-02
      DATE                  : 11/8/84
      TEST PERIOD           :
55-2023 (1255-1345/1503-1613/1905-1917/1940-2023)


          PARAMETER                   RESULT
          ---------                   ------

          Vm(dscf)                     130.9752
          Vm(dscm)                     3.709216
          Vw gas(scf)                  10.79735
          Vw gas (scm)                 .305781
          % moisture                   7.615969
          Md                           .9238404
          MWd                          29.342
          MW                           28.4782
          Vs(fpm)                      2296.759
          Vs (mpm)                     700.2315
          Flow(acfm)                   15345.46
          Flow(acmm)                   434.5835
          Flow(dscfm)                  9412.269
          Flow(dscmm)                  266.5555
          % I                          103.8584
          % EA                         759.7911



                                          Program Revision:1/16/84
          RADIAN SOURCE TEST
          EPA METHOD 2-5
           (RAW DATA)
       PLANT                 : DIOXIN SITE #02
       PLANT SITE            :
       SAMPLING LOCATION     :
   INCINERATOR (NORTH UNIT) EXHAUST
       TEST #                : 02-MM5-03
       DATE                  : 11/09/84
       TEST PERIOD           :
1857  (1102-1132/1141-1311/1424-1444/1627-1647/1737-1857)

      PARAMETER                                 VALUE
      ---------                                 -----

      Sampling time (min.)                       240
      Barometric Pressure (in.Hg)                29.18
      Sampling nozzle diameter (in.)             .309
      Meter Volume (cu.ft.)                      173.208
      Meter Pressure (in.H2O)                    1.792083
      Meter Temperature (F)                      72.89585
      Stack dimension (sq.in.)                   962.115
      Stack Static Pressure (in.H2O)            -.38
      Stack Moisture Collected (gm)              327.6
      Absolute stack pressure(in Hg)             29.15206
      Average stack temperature (F)              368.7083
      Percent CO2                                4.96
      Percent O2                                 16.58
      Percent N2                                 78.46
      Delps Subroutine result                    14.10055
      DGM Factor                                 .9973
      Pitot Constant                             .84
```

```
          RADIAN SOURCE TEST
          EPA METHODS 2-5
          FINAL RESULTS
        PLANT                 : DIOXIN SITE #02
        PLANT SITE            :
        SAMPLING LOCATION     :
    INCINERATOR (NORTH UNIT) EXHAUST
        TEST #                : 02-MM5-03
        DATE                  : 11/09/84
        TEST PERIOD           :
2-1857   (1102-1132/1141-1311/1424-1444/1627-1647/1737-1857)


          PARAMETER                 RESULT
          ---------                 ------

          Vm(dscf)                   167.674
          Vm(dscm)                   4.748528
          Vw gas(scf)                15.44634
          Vw gas (scm)               .4374404
          % moisture                 8.435076
          Md                         .9156492
          MWd                        29.4568
          MW                         28.49041
          Vs(fpm)                    2108.133
          Vs (mpm)                   642.7233
          Flow(acfm)                 14085.18
          Flow(acmm)                 398.8923
          Flow(dscfm)                8006.293
          Flow(dscmm)                226.7382
          % I                        112.0208
          % EA                       401.1187




                                          Program Revision:1/16/84
```

RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : DIOXIN SITE #02
PLANT SITE :
SAMPLING LOCATION :
INCINERATOR (NORTH UNIT) EXHAUST
TEST # : 02-MM5-04
DATE : 11/12/84
TEST PERIOD : 1021-1503 (1021-1221 / 1303-1503)

PARAMETER	VALUE
Sampling time (min.)	240
Barometric Pressure (in.Hg)	29.65
Sampling nozzle diameter (in.)	.309
Meter Volume (cu.ft.)	176.485
Meter Pressure (in.H2O)	1.89
Meter Temperature (F)	71.16666
Stack dimension (sq.in.)	962.115
Stack Static Pressure (in.H2O)	-.38
Stack Moisture Collected (gm)	309.5
Absolute stack pressure(in Hg)	29.62206
Average stack temperature (F)	350.25
Percent CO2	4.4
Percent O2	18.2
Percent N2	77.4
Delps Subroutine result	14.19743
DGM Factor	.9973
Pitot Constant	.84

RADIAN SOURCE TEST
EPA METHODS 2-5
FINAL RESULTS

PLANT : DIOXIN SITE #02
PLANT SITE :
SAMPLING LOCATION :
INCINERATOR (NORTH UNIT) EXHAUST
TEST # : 02-MM5-04
DATE : 11/12/84
TEST PERIOD : 1021-1503 (1021-1221 / 1303-1503)

PARAMETER	RESULT
Vm(dscf)	174.193
Vm(dscm)	4.933145
Vw gas(scf)	14.59293
Vw gas (scm)	.4132716
% moisture	7.729881
Md	.9227012
MWd	29.432
MW	28.54832
Vs(fpm)	2103.573
Vs (mpm)	641.3333
Flow(acfm)	14054.72
Flow(acmm)	398.0296
Flow(dscfm)	8366.653
Flow(dscmm)	236.9436
% I	111.3636
% EA	814.8286

Program Revision:1/16/84

APPENDIX A-2
CONTINUOUS EMISSION MONITORING RESULTS

CEM Data at 3% O_2

Site ISW-A Test 1

TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	NOX (PPMV)
1045	9.7	496.5	15.3	214.2
1050	8.8	474.7	15.1	224.4
1055	10.5	572.8	14.1	184.9
1100	7.9	499.6	15.9	213.6
1105	9.0	457.5	14.4	188.7
1110	11.2	659.4	14.4	155.1
1115	12.7	640.6	16.1	137.7
1120	13.6	636.2	16.2	137.2
1125	9.9	537.1	14.6	124.1
1130	9.4	538.3	15.4	122.8
1135	9.9	468.3	16.2	145.0
1140	7.4	553.6	12.5	125.5
1145	9.7	570.8	16.6	151.7
1150	9.9	525.9	13.6	129.5
1155	10.1	638.9	17.1	133.5
1200	10.1	649.6	14.4	132.4
1205	8.8	586.8	14.7	124.4
1210	10.4	494.2	16.2	140.1
1215	9.5	469.6	15.7	136.0
1220	10.1	513.2	14.9	133.8
1225	10.8	742.8	16.2	129.9
1230	10.0	484.7	16.6	144.0
1235	9.0	420.3	15.9	120.7
1240	10.6	777.4	16.5	123.2
1245	10.5	713.7	13.8	116.3
1250	10.3	691.8	13.7	122.4
1340	10.1	683.1	16.1	165.2
1345	11.2	1059.0	16.2	134.0
1350	11.2	748.0	16.7	145.2
1355	9.4	545.6	19.1	140.3
1400	9.5	806.0	17.1	107.4
1405	9.5	645.3	18.9	133.1
1410	10.1	636.5	15.2	116.1
1415	9.7	466.7	17.7	118.9
1420	10.7	684.7	17.3	126.3
1425	11.6	738.8	15.4	136.0
1430	9.9	612.5	16.3	130.5
1435	11.5	670.4	14.7	118.5
1440	10.1	561.2	15.8	127.7
1445	10.7	696.7	15.0	104.7
1450	10.8	600.8	18.1	104.6
1455	11.9	691.1	17.7	98.8
1500	13.1	900.8	15.3	97.0
1505	14.0	1041.7	18.6	99.3
1510	11.4	937.4	16.8	145.1
1515	11.5	736.9	16.7	109.7
1520	10.4	692.7	17.9	131.5
1525	12.1	707.0	16.0	101.3
1530	12.4	872.2	15.9	93.6
1535	11.7	713.7	16.0	91.9
1540	10.2	644.4	18.4	97.7
1545	11.6	682.6	12.9	89.1
1550	9.6	610.4	16.3	90.9
NO. PTS.	53	53	53	53
MEAN	10.5	645.3	15.9	131.4
STD. DEV.	1.3	140.0	1.4	29.8

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CEM Data at 3% O_2

Site ISW-A Test 2

TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	NOX (PPMV)	THC (PPMV)
1300	9.0	315.9	14.1	112.0	14.7
1305	10.3	242.3	12.8	112.8	15.3
1310	12.4	401.5	14.9	107.4	17.4
1315	11.5	395.9	18.3	116.4	14.0
1320	11.2	134.8	17.6	111.0	18.9
1325	11.3	458.2	21.2	148.5	15.8
1330	8.9	294.6	12.9	90.2	5.9
1335	9.6	264.5	16.2	92.3	5.9
1340	11.9	328.0	14.9	108.2	13.0
1345	11.0	264.2	17.6	104.9	14.4
1500	10.1	111.9	17.1	164.8	9.0
1505	10.9	198.0	16.1	148.4	9.8
1510	10.0	79.0	14.7	102.4	9.6
1515	12.1	302.3	15.3	99.9	11.7
1520	12.2	228.9	15.8	98.7	12.4
1525	11.9	308.4	15.5	235.7	11.0
1530	13.8	400.6	17.5	171.6	15.1
1535	13.0	313.4	17.6	141.0	10.9
1540	11.7	242.2	14.9	114.4	9.2
1545	12.5	172.0	17.0	131.9	12.1
1550	11.1	202.8	20.5	183.2	9.8
1555	13.1	248.2	16.6	118.1	11.2
1600	10.5	207.8	16.2	155.2	8.5
1605	9.7	114.3	16.5	211.0	7.3
1610	10.2	244.5	14.9	177.1	8.8
1615	10.7	186.7	16.1	149.5	8.7
1905	12.0	222.7	16.9	148.8	10.6
1910	12.2	100.5	17.9	112.9	11.3
1915	13.9	97.3	17.4	114.4	
1920	15.0	137.0	17.8	113.2	18.3
1940	12.6	232.0	14.1	132.5	10.8
1945	15.3	344.1	17.0	136.1	14.9
1950	14.0	49.6	18.0	142.4	11.5
1955	12.2	63.1	17.0	124.0	10.4
2000	9.2	188.1	19.1	122.9	6.2
2005	11.3	52.2	15.4	131.7	11.1
2010	11.0	166.5	16.5	118.7	7.8
2015	12.8	405.8	14.1	112.3	11.4
2020	14.1	460.7	14.3	109.8	18.4
2025	14.6	500.9	17.3	105.9	18.7
2030	14.9	472.7	16.3	102.1	18.0
NO. PTS.	41	41	41	41	40
MEAN	11.8	247.7	16.4	130.1	12.0
STD. DEV.	1.7	121.5	1.8	31.2	3.6

CEM Data 3% O_2

Site ISW-A Test 3

TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	NOX (PPMV)	THC (PPMV)
1105	11.4	248.1	15.2	113.8	7.1
1110	12.2	319.8	16.3	167.1	6.7
1115	14.1	382.2	17.3	195.8	12.7
1120	14.3	572.3	15.4		
1200	9.0	185.9	13.2	131.2	4.3
1205	9.2	322.8	16.2	146.7	4.3
1210	9.6	358.9	14.9	135.2	5.0
1215	9.9	308.9	16.6	131.9	4.9
1220	9.9	326.5	16.6	143.6	4.7
1225	9.7	266.7	16.0	142.3	4.5
1230	10.0	181.3	15.0	165.7	5.2
1235	10.2	159.9	15.6	165.5	5.0
1240	12.2	166.1	13.3	155.6	6.1
1245	8.9	255.9	14.3	145.6	4.5
1250	9.9	335.3	14.9	155.6	4.5
1255	12.4	173.2	14.6	142.2	7.1
1300	10.1	235.1	16.1	186.1	5.0
1305	12.4	364.4	16.8	170.1	5.8
1310	13.9	415.0	17.1	169.0	6.0
1315	10.2	436.8	14.5	170.4	4.0
1420	10.1	158.1	14.6	124.8	4.2
1425	10.8	516.1	15.7	133.2	3.9
1430	10.9	271.6	15.2	134.4	3.5
1435	10.9	400.9	14.8	138.8	3.5
1440	11.6	52.3	14.3	139.5	3.9
1445	13.3	158.8	16.7	137.8	6.2
1625	13.6	695.7	15.1	104.8	7.8
1630	12.6		16.8	113.7	6.7
1635	10.7	119.0	18.3	152.9	4.7
1640	12.1	26.9	15.1	143.1	5.5
1645	10.3		16.1	147.7	4.2
1650	11.0	189.4	16.8	123.2	3.9
1735	11.8	168.0	18.5	110.6	4.2
1740	10.5	133.8	14.5	111.4	4.1
1745	12.6	129.8	17.0	118.9	7.9
1750	12.1	410.0	15.7	119.6	5.8
1755	11.3	105.9	14.6	135.3	5.1
1800	13.3	255.5	18.1	123.1	7.6
1805	10.1	49.8	21.0	207.2	3.3
1810	11.8	58.9	17.3	114.8	3.8
1815	11.5		17.2	114.2	3.8
1820	12.6	564.8	14.2	100.1	4.8
1825	13.7	432.7	17.0	109.6	6.1
1830	11.9	505.7	17.2	176.0	4.3
1835	14.0	368.3	19.6	125.3	7.9
1840	12.4		16.1	116.0	
1845	12.4	409.6	17.4	107.5	
1850	14.8	696.6	19.5	104.7	
1855	15.3	503.4	21.1	107.3	
NO. PTS.	49	45	49	48	44
MEAN	11.6	297.7	16.2	138.1	5.3
STD. DEV.	1.6	166.1	1.7	25.3	1.7

CEM Data at 3% O_2

Site ISW-A Test 4

TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	NOX (PPMV)	THC (PPMV)
1030	11.1	264.4	18.3	157.0	13.0
1035	12.3	360.5	15.4	112.2	8.3
1040	9.8	92.0	17.0	185.8	6.4
1045	8.7	274.6	12.7	104.7	4.7
1050	9.0	225.6	16.9	115.3	7.3
1055	10.5	404.3	15.0	122.2	6.2
1100	10.6	324.5	15.3	109.4	4.7
1105	11.7	356.1	13.6	106.1	4.7
1110	9.2	219.3	15.1	116.0	3.3
1115	11.8	279.5	15.7	109.5	4.1
1120	8.7	289.5	17.7	127.8	2.7
1125	11.9		11.4	131.1	2.9
1130	13.2	409.6	15.2	122.2	4.0
1135	12.0	415.6	15.1	112.3	3.3
1140	14.3	414.1	14.0	117.4	4.7
1145	10.6	277.1	15.8	111.2	3.5
1150	11.6	222.8	13.9	112.2	3.9
1155	9.6	220.8	14.0	147.7	3.1
1200	11.3	257.1	17.2	126.3	3.6
1205	11.9	200.8	15.4	114.0	4.0
1210	11.7	411.7	16.4	119.0	4.1
1215	10.0	275.2	14.1	110.5	3.5
1305	12.4	463.3	13.8	109.6	3.9
1310	13.9	361.4	15.5	102.3	5.2
1315	13.0	318.1	14.9	90.2	10.0
1320	12.2	225.5	20.7	138.1	4.0
1325	11.4	180.6	15.1	127.9	3.4
1330	13.1	198.3	15.0	93.3	4.6
1335	10.5	249.8	15.5	106.3	3.0
1340	13.4	219.0	15.6	115.0	3.7
1345	11.4	271.2	14.3	111.9	2.9
1350	9.9	115.9	13.7	108.1	2.3
1355	10.9	327.9	15.4	151.8	2.4
1400	12.0	409.9	14.6	107.6	3.1
1405	13.6	423.6	15.0	106.5	3.2
1410	12.9	286.8	15.9	107.8	2.9
1415	14.5	146.2	14.0	95.7	3.7
1420	11.8	118.4	13.6	88.3	2.7
1425	12.0	150.3	16.1	85.7	2.7
1430	13.3	547.2	17.0	84.2	3.7
1435	11.9	258.2	14.8	92.5	4.7
1440	13.9	256.8	15.0	81.0	4.9
1445	11.5	480.5	13.1	74.1	3.7
1450	12.3	468.4	14.7	123.1	4.9
1455	11.6	233.1	17.0	125.3	4.2
1500	12.6	80.0	13.3	110.7	4.5
NO. PTS.	46	45	46	46	46
MEAN	11.7	288.6	15.2	113.6	4.3
STD. DEV.	1.4	109.2	1.6	20.2	2.0

APPENDIX A-3
HCl ACID TRAIN RESULTS

RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : DIOXIN SITE #02
PLANT SITE :
SAMPLING LOCATION :
PLANT WASTE INCINERATOR (NORTH UNIT) EXHAUST
TEST # : 02-HCL-01
DATE : 11/07/84
TEST PERIOD : 1104-1552 (1104-1252 / 1412-1552)

PARAMETER	VALUE
Sampling time (min.)	208
Barometric Pressure (in.Hg)	29.19
Sampling nozzle diameter (in.)	.302
Meter Volume (cu.ft.)	144.181
Meter Pressure (in.H2O)	1.8
Meter Temperature (F)	80.18
Stack dimension (sq.in.)	962.115
Stack Static Pressure (in.H2O)	-.38
Stack Moisture Collected (gm)	191.83
Absolute stack pressure(in Hg)	29.16206
Average stack temperature (F)	290.3637
Percent CO2	4.84
Percent O2	17.58
Percent N2	77.58
Delps Subroutine result	13.56493
DGM Factor	.9945
Pitot Constant	.84

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              RADIAN SOURCE TEST
              EPA METHODS 2 - 5
              FINAL RESULTS
            PLANT                    : DIOXIN SITE #02
            PLANT SITE               :
            SAMPLING LOCATION        :
PLANT WASTE INCINERATOR (NORTH UNIT) EXHAUST
            TEST #                   : 02-HCL-01
            DATE                     : 11/07/84
            TEST PERIOD              : 1104-1552 (1104-1252 / 1412-1552)

              PARAMETER                     RESULT
              ---------                     ------

              Vm(dscf)                       137.3553
              Vm(dscm)                       3.889903
              Vw gas(scf)                    9.044784
              Vw gas (scm)                   .2561483
              % moisture                     6.178128
              Md                             .9382187
              MWd                            29.4776
              MW                             28.7685
              Vs(fpm)                        2017.882
              Vs (mpm)                       615.2078
              Flow(acfm)                     13482.18
              Flow(acmm)                     381.8154
              Flow(dscfm)                    8675.269
              Flow(dscmm)                    245.6836
              % I                            102.3005
              % EA                           605.9727




                                             Program Revision:1/16/
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                R A D I A N   S O U R C E   T E S T
                E P A   M E T H O D   5
             P A R T I C U L A T E   L O A D I N G
              PLANT                 : DIOXIN SITE #02
              PLANT SITE            :
              SAMPLING LOCATION     :
PLANT WASTE INCINERATOR (NORTH UNIT) EXHAUST
              TEST #                : 02-HCL-01
              DATE                  : 11/07/84
              TEST PERIOD           : 1104-1552 (1104-1252 / 1412-1552)

          PARAMETER             FRONT-HALF          BACK HALF
          ---------             ----------          -----

          Total Grams           0.1225000           5.7139000
          Grams/dscf            0.0008918           0.0415994
          Grams/acf             0.0005739           0.0267676
          Grains/dscf           0.0137612           0.6418789
          Grains/acf            0.0088548           0.4130246
          Grams/dscm            0.0314911           1.4688750
          Grams/acm             0.0202633           0.9451652
          Pounds/dscf           0.0000020           0.0000917
          Pounds/acf            0.0000013           0.0000590
          Pounds/Hr             1.0236070          47.7452300
          Kilograms/Hr          0.4643052          21.6570900




                                                   Program Revision:1/16/84
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RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : DIOXIN SITE #02
PLANT SITE :
SAMPLING LOCATION :
PLANT WASTE INCINERATOR (NORTH UNIT) EXHAUST
TEST # : 02-HCL-03
DATE : 11-09-84
TEST PERIOD :
1104-1859 (1104-1310/1328-1346/1629-1649/1739-1859)

PARAMETER	VALUE
Sampling time (min.)	244
Barometric Pressure (in.Hg)	29.18
Sampling nozzle diameter (in.)	.302
Meter Volume (cu.ft.)	171.4041
Meter Pressure (in.H2O)	1.8
Meter Temperature (F)	64.875
Stack dimension (sq.in.)	962.115
Stack Static Pressure (in.H2O)	-.38
Stack Moisture Collected (gm)	318.27
Absolute stack pressure(in Hg)	29.15206
Average stack temperature (F)	351.25
Percent CO2	4.96
Percent O2	16.58
Percent N2	78.46
Delps Subroutine result	14.24123
DGM Factor	.9945
Pitot Constant	.84

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                  R A D I A N   S O U R C E   T E S T
                  E P A   M E T H O D S   2 - 5
                  F I N A L   R E S U L T S
                PLANT                  : DIOXIN SITE #02
                PLANT SITE             :
                SAMPLING LOCATION      :
PLANT WASTE INCINERATOR (NORTH UNIT) EXHAUST
                TEST #                 : 02-HCL-03
                DATE                   : 11-09-84
                TEST PERIOD            :
1104-1859 (1104-1310/1328-1346/1629-1649/1739-1859)


                  PARAMETER                  RESULT
                  ---------                  ------

                  Vm(dscf)                    167.9938
                  Vm(dscm)                    4.757583
                  Vw gas(scf)                 15.00643
                  Vw gas (scm)                .4249821
                  % moisture                  8.200228
                  Md                          .9179977
                  MWd                         29.4568
                  MW                          28.51732
                  Vs(fpm)                     2128.162
                  Vs (mpm)                    648.8297
                  Flow(acfm)                  14219
                  Flow(acmm)                  402.6821
                  Flow(dscfm)                 8277.468
                  Flow(dscmm)                 234.4179
                  % I                         111.7852
                  % EA                        401.1187





                                          Program Revision:1/16/84
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                 R A D I A N   S O U R C E   T E S T
                 E P A   M E T H O D   5
              P A R T I C U L A T E   L O A D I N G
               PLANT                   : DIOXIN SITE #02
               PLANT SITE              :
               SAMPLING LOCATION       :
PLANT WASTE INCINERATOR (NORTH UNIT) EXHAUST
               TEST #                  : 02-HCL-03
               DATE                    : 11-09-84
               TEST PERIOD             :
1104-1859 (1104-1310/1328-1346/1629-1649/1739-1859)


          PARAMETER             FRONT-HALF          BACK HALF
          ---------             ----------          -----

          Total Grams           0.2424000           11.8580000
          Grams/dscf            0.0014429            0.0705860
          Grams/acf             0.0008400            0.0410910
          Grains/dscf           0.0222641            1.0891410
          Grains/acf            0.0129609            0.6340342
          Grams/dscm            0.0509492            2.4923900
          Grams/acm             0.0296596            1.4509240
          Pounds/dscf           0.0000032            0.0001556
          Pounds/acf            0.0000019            0.0000906
          Pounds/Hr             1.5801450           77.2993200
          Kilograms/Hr          0.7167489           35.0627400




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RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : DIOXIN SITE #02
PLANT SITE :
SAMPLING LOCATION :
PLANT WASTE INCINERATOR (NORTH UNIT) EXHAUST
TEST # : 02-HCL-04
DATE : 11/12/84
TEST PERIOD : 1023-1500 (1023-1218 / 1305-1500)

PARAMETER	VALUE
Sampling time (min.)	220
Barometric Pressure (in.Hg)	29.65
Sampling nozzle diameter (in.)	.302
Meter Volume (cu.ft.)	163.672
Meter Pressure (in.H2O)	1.8
Meter Temperature (F)	63.96
Stack dimension (sq.in.)	962.115
Stack Static Pressure (in.H2O)	-.38
Stack Moisture Collected (gm)	276.4
Absolute stack pressure(in Hg)	29.62206
Average stack temperature (F)	346.1667
Percent CO2	4.4
Percent O2	18.2
Percent N2	77.4
Delps Subroutine result	14.19654
DGM Factor	.9945
Pitot Constant	.84

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                  R A D I A N   S O U R C E   T E S T
                  E P A   M E T H O D S   2 - 5
                  F I N A L   R E S U L T S
                PLANT                  : DIOXIN SITE #02
                PLANT SITE             :
                SAMPLING LOCATION      :
      PLANT WASTE INCINERATOR (NORTH UNIT) EXHAUST
                TEST #                 : 02-HCL-04
                DATE                   : 11/12/84
                TEST PERIOD            : 1023-1500 (1023-1218 / 1305-1500)

                  PARAMETER                   RESULT
                  ---------                   ------

                  Vm(dscf)                     163.2722
                  Vm(dscm)                     4.623869
                  Vw gas(scf)                  13.03226
                  Vw gas (scm)                 .3690736
                  % moisture                   7.391906
                  Md                           .9260809
                  MWd                          29.432
                  MW                           28.58696
                  Vs(fpm)                      2102.02
                  Vs (mpm)                     640.8596
                  Flow(acfm)                   14044.34
                  Flow(acmm)                   397.7356
                  Flow(dscfm)                  8433.599
                  Flow(dscmm)                  238.8395
                  % I                          118.2647
                  % EA                         814.8286




                                         Program Revision:1/16/8
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RADIAN SOURCE TEST
EPA METHOD 5
PARTICULATE LOADING

PLANT : DIOXIN SITE #02
PLANT SITE :
SAMPLING LOCATION :
PLANT WASTE INCINERATOR (NORTH UNIT) EXHAUST
TEST # : 02-HCL-04
DATE : 11/12/84
TEST PERIOD : 1023-1500 (1023-1218 / 1305-1500)

PARAMETER	FRONT-HALF	BACK HALF
Total Grams	0.0471000	8.6726000
Grams/dscf	0.0002885	0.0531174
Grams/acf	0.0001732	0.0318969
Grains/dscf	0.0044512	0.8196019
Grains/acf	0.0026729	0.4921694
Grams/dscm	0.0101861	1.8755760
Grams/acm	0.0061167	1.1262800
Pounds/dscf	0.0000006	0.0001171
Pounds/acf	0.0000004	0.0000703
Pounds/Hr	0.3218706	59.2665700
Kilograms/Hr	0.1459996	26.8831400

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APPENDIX A-4

AMBIENT AIR-XAD TRAIN FIELD RESULTS

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RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : DIOXIN SITE #02
PLANT SITE :
SAMPLING LOCATION : ROOF TOP NEXT TO AMBIENT AIR DAMPER
TEST # : TOTAL AMBIENT RUN 4 DAYS TOTAL
DATE : 11/7-8-9-12/84
TEST PERIOD : METER VOLUME FOR THE AMBIENT SAMPLE

PARAMETER	VALUE
Sampling time (min.)	985
Barometric Pressure (in.Hg)	29.92
Sampling nozzle diameter (in.)	.5
Meter Volume (cu.ft.)	473.188
Meter Pressure (in.H2O)	.001
Meter Temperature (F)	68
Stack dimension (sq.in.)	
Stack Static Pressure (in.H2O)	.001
Stack Moisture Collected (gm)	
Absolute stack pressure(in Hg)	29.92008
Average stack temperature (F)	50
Percent CO2	0
Percent O2	21
Percent N2	79
Delps Subroutine result	
DGM Factor	1
Pitot Constant	

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RADIAN SOURCE TEST
EPA METHODS 2-5
FINAL RESULTS

```
PLANT              : DIOXIN SITE #02
PLANT SITE         :
SAMPLING LOCATION  : ROOF TOP NEXT TO AMBIENT AIR DAMPER
TEST #             : TOTAL AMBIENT RUN 4 DAYS TOTAL
DATE               : 11/7-8-9-12/84
TEST PERIOD        : METER VOLUME FOR THE AMBIENT SAMPLE

   PARAMETER               RESULT
   ---------               ------

   Vm(dscf)                 473.1892
   Vm(dscm)                 13.40072
   Vw gas(scf)
   Vw gas (scm)
   % moisture
   Md                       .9953485
   MWd                      28.84
   MW                       28.789
   Vs(fpm)
   Vs (mpm)
   Flow(acfm)
   Flow(acmm)
   Flow(dscfm)
   Flow(dscmm)
   % I
   % EA

                                          Program Revision:1/16/84
```

APPENDIX A-5
EPA METHOD 3 FIXED GAS FIELD RESULTS

Fixed Gas Analysis Results for ISW-A[a]

Run Number	Sample Number[b]	Fixed Gas Concentrations[c]			Total[d] Percentages
		O_2	CO_2	N_2	
1	1	18.54	4.00	80.77	103.3
	2	17.55	4.36	77.12	99.0
	3	18.89	4.26	81.51	104.7
	4	16.22	5.44	76.15	97.8
	5	16.90	5.95	78.78	101.6
	6	17.46	4.81	78.25	100.5
	7	17.51	5.09	80.43	103.0
	Average	17.58	4.84	79.00	101.4
2	1	18.29	4.07	81.72	104.1
	2	18.32	2.71	77.16	99.2
	3	17.95	3.75	77.0	98.7
	Average	18.19	3.84	78.6	100.6
3	1	16.90	4.81	77.48	99.2
	2	16.26	5.45	77.22	98.9
	3	16.80	5.17	79.28	101.3
	4	17.04	4.32	76.00	97.4
	5	16.53	4.71	77.00	98.2
	6	15.95	5.29	76.68	97.9
	Average	16.58	4.96	77.27	98.8
4	1	18.63	4.19	81.47	104.3
	2	18.49	4.30	81.34	104.1
	3	17.71	4.77	80.35	102.8
	4	17.97	5.01	81.07	104.1
	5	17.42	5.11	79.83	102.4
	6	17.18	3.24	77.34	97.8
	Average	17.90	4.44	80.23	102.6

[a] Analysis by gas chromatograph/thermal conductivity detector.

[b] Represents tedlar bags of flue gas collected according to EPA Method 3

[c] Concentrations presented represent average values from duplicate sample analyses.

[d] Sum of fixed gas concentrations. Differences from 100 percent are due to analytical error.

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APPENDIX A-6

MODIFIED METHOD 5 AND EPA METHODS 1-4 SAMPLE CALCULATIONS

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RADIAN SOURCE TEST
EPA METHOD 2-5
SAMPLE CALCULATION

PLANT : DIOXIN SITE #02
PLANT SITE :
SAMPLING LOCATION :
INCINERATOR (NORTH UNIT) EXHAUST
TEST # : 02-MM5-01
DATE : 11/07/84
TEST PERIOD : 1047-1545 (1047-1247 / 1345-1545)

1) Volume of dry gas sampled at standard conditions (68 deg-F ,29.92 in. Hg).

$$Vm(std) = \frac{Y \times Vm \times [T(std) + 460] \times [Pb + (Pm/13.6)]}{P(std) \times (Tm + 460)}$$

$$Vm(std) = \frac{.9973 \times 181.776 \times 528 \times [29.19 + (1.937708/13.6)]}{29.92 \times (87.4 + 460)}$$

$$Vm(std) = 171.427 \text{dscf}$$

2) Volume of water vapor at standard conditions:

$$Vw(gas) = 0.04715 \text{ cf/gm} \times W(l) \text{ gm}$$

$$Vw(gas) = 0.04715 \times 292.7 = 13.801 \text{ scf}$$

3) Percent Moisture in stack gas :

$$\%M = \frac{100 \times Vw(gas)}{Vm(std) + Vw(gas)}$$

$$\%M = \frac{100 \times 13.801}{171.427 + 13.801} = 7.45\ \%$$

4) Mole fraction of dry stack gas :

$$Md = \frac{100 - \%M}{100} = \frac{100 - 7.45}{100} = .9254927$$

SAMPLE CALCULATION
PAGE TWO

```
5)Average Molecular Weight of DRY stack gas :

        MWd = (.44 x %CO2) + (.32 x %O2) + (.28 x %N2)

        MWd = (.44 x 4.84 ) + (.32 x 17.58 ) + (.28 x  77.58 ) =  29.4776

6)Average Molecular Weight of wet stack gas :

        MW   = MWd x Md + 18(1 - Md)

        MW  = 29.4776  x  .9254927  + 18(1 -  .9254927 )  =  28.62244

7) Stack gas velocity in feet-per-minute (fpm) at stack conditions :


Vs = KpxCp x [SQRT (dP)]$avet x SQRT [Ts $avgt] x SQRT [1/(PsxMW)] x 60sec/mir

    Vs = 85.49 x .84 x 60 x  13.87255 x SQRT[1/( 29.16206  X  28.62244 )]

    Vs =  2068.901  FPM

8) Average stack gas dry volumetric flow rate (DSCFM) :

              Vs x As x Md x T(std) x Ps
   Qsd =  ----------------------------------------
          144 cu.in./cu.ft. x (Ts +460) x P(std)

           2068.901 x 962.115 x .9254927 x528x 29.16206
   Qsd =  ----------------------------------------
           144 x  746.7917  x 29.92

   Qsd =  8815.934 dscfm
```

SAMPLE CALCULATION
PAGE THREE

```
9)Isokinetic sampling rate (%) :

        Dimensional Constant C = K4 x 60 x 144 x [1 / (Pi  /4)]
        K4 = .0945 FOR ENGLISH UNITS

                   C x Vm(std) x (Ts + 460)
        I% =     -------------------------------------
                 Vs x Tt x Ps x Md x (Dn)°2

                   1039.574 x 171.4268 x 746.7917
        I% = -----------------------------------------
             2068.901 x 240 x 29.16206 x .9254927 x( .309 )°2

        I% =  104.0099

10) Excess air (%) :

                 100 x %O2           100 x 17.58
        EA =     --------------- = ---------------
                 (.264 x %N2) - %O2  (.264 x 77.58 ) - 17.58

        EA =      605.97

11) Particulate Concentration :

        Cs = ( grams part.) / Vm(std) =  0 / 171.4268

        Cs =       0.0000000 Grams/DSCF

                 T(std) x Md x Ps x Cs
        Ca =     ------------------------------
                 P(std) x Ts

                 528 x .9254927  x 29.16206  x      0.0000000
        Ca =     ------------------------------
                 29.92      x     746.7917

        Ca =            0.0000000 Grams/ACF

        LBS/HR =  Cs x 0.002205 x Qsd x 60

        LBS/HR =        0.0000000x 0.002205 x  8815.9 x 60

        LBS/HR = 0
```

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RADIAN SCURCE TEST
EPA METHODS 2-5
DEFINITION OF TERMS

PARAMETER	DEFINITION
Tt(min.)	TOTAL SAMPLING TIME
Dn(in.)	SAMPLING NOZZLE DIAMETER
Ps(in.H2O)	ABSOLUTE STACK STATIC GAS PRESSURE
Vm(cu.ft.)	ABSOLUTE VOLUME OF GAS SAMPLE MEASURED BY DGM
Vw(gm.)	TOTAL STACK MOISTURE COLLECTED
Pm(in.H2O)	AVERAGE STATIC PRESSURE OF DGM
Tm(F)	AVERAGE TEMPERATURE OF DGM
Pb(in.Hg.)	BAROMETRIC PRESSURE
% CO2	CARBON DIOXIDE CONTENT OF STACK GAS
% O2	OXYGEN CONTENT OF STACK GAS
% N2	NITROGEN CONTENT OF STACK GAS
SQR(DELPS)	AVE. SQ. ROOT OF S-PITOT DIFF. PRESSURE-TEMP. PRODUCT
As(sq.in.)	CROSS-SECTIONAL AREA OF STACK(DUCT)
Ts(F)	TEMPERATURE OF STACK
Vm(dscf)	STANDARD VOLUME OF GAS SAMPLED ,Vm(std),AS DRY STD. C
Vm(dscm)	STANDARD VOLUME OF GAS SAMPLED,Vm(std),AS DRY STD. CM
Vw gas(scf)	VOLUME OF WATER VAPOR IN GAS SAMPLE,STD
% moisture	WATER VAPOR COMPOSITION OF STACK GAS
Md	PROPORTION, BY VOLUME,OF DRY GAS IN GAS SAMPLE
MWd	MOLECULAR WEIGHT OF STACK GAS,DRY BASIS LB/LB-MOLE
MW	MOLECULAR WEIGHT OF STACK GAS,WET BASIC LB/LB-MOLE
Vs(fpm)	AVERAGE STACK GAS VELOCITY
Flow(acfm)	AVERAGE STACK GAS FLOW RATE(ACTUAL STACK COND.)
Flow(acmm)	AVERAGE STACK GAS FLOW RATE(ACTUAL STACK COND.)
Flow(dscfm)	AVERAGE STACK GAS VOLUMETRIC FLOW RATE(DRY BASIS)
Flow(dscmm)	AVERAGE STACK GAS VOLUMETRIC FLOW RATE(DRY BASIS)
% I	PERCENT ISOKINETIC
% EA	PERCENT EXCESS AIR IN STACK GAS
DGM	DRY GAS METER
Y	DRY GAS METER CORRECTION FACTOR
Pg	STACK STATIC GAS PRESSURE
Cp	PITOT COEFFICIENT
dH	ORIFICE PLATE DIFF. PRESS. VALUE
dP	PITOT DIFF. PRESS. VALUE
*** EPA STANDARD CONDITIONS	Temperature = 68 deg-F (528 deg-R) Pressure = 29.92 in. Hg.

APPENDIX B
PROCESS MONITORING DATA

APPENDIX B

CODE TO PROCESS DATA TABLES

(1) Feed weights in units of pounds.

(2) Feed type are as follows:

1 = Crate wood, paper, cardboard
2 = Treated wood
3 = Painted wood
4 = Wood/plastic cutoffs
5 = Hytest paint sludge
6 = Latex paint sludge

(3) Temperatures in units of °F.

(4) Water rates in units of gpm.

(5) Boiler rate in units of lb/hr steam.

(6) Boiler pressure in units of psig.

(7) Oil usage in units of gallons.

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date	time	feed weight	feed type	main temp	stack temp	main water	stack water	boiler rate	boiler pressure
11784	936	207	2	.	.	.	.	.	.
11784	936	153	1	.	.	.	.	.	.
11784	937	140	3	.	.	.	.	.	.
11784	937	163	1	.	.	.	.	.	.
11784	939	405	1	.	.	.	.	.	.
11784	948	353	1	.	.	.	.	.	.
11784	955	70	1	.	.	.	.	.	.
11784	955	309	2	.	.	.	.	.	.
11784	1001	156	1	.	.	.	.	.	.
11784	1005	194	1	1400	1150	.	.	.	.
11784	1009	164	1	1400	1400	50	5	.	.
11784	1012	201	1	1350	1300	40	5	.	.
11784	1018	116	1	.	.	.	.	.	.
11784	1018	238	3	.	.	.	.	.	.
11784	1020	265	1	.	.	.	.	.	.
11784	1024	138	1	.	.	.	.	.	.
11784	1027	195	1	.	.	.	.	.	.
11784	1029	58	1	1200	1650	40	5	8000	12
11784	1032	237	3	.	.	.	.	.	.
11784	1036	118	1	.	.	.	.	.	.
11784	1040	39	3	1200	1650	40	5	.	12
11784	1044	224	3	.	.	.	.	.	.
11784	1047	188	1	.	.	.	.	.	.
11784	1052	120	1	1200	1600	.	.	.	.
11784	1052	29	5	.	.	.	.	.	.
11784	1056	768	3	.	.	.	.	.	.
11784	1122	745	1	1550	1400	40	5	.	11
11784	1125	154	1	.	.	.	.	.	.
11784	1140	148	1	1300	1700	40	5	.	.
11784	1142	156	1	.	.	.	.	.	.
11784	1148	430	1	1200	1650	.	.	.	.
11784	1158	283	1	1200	1750	.	.	.	.
11784	1158	34	5	.	.	.	.	.	.
11784	1158	400	4	.	.	.	.	.	.
11784	1207	150	1	.	.	.	.	.	.
11784	1207	340	4	.	.	.	.	.	.
11784	1213	148	1	1300	1650	40	5	.	.
11784	1217	155	1	.	.	.	.	.	.
11784	1222	114	1	.	.	.	.	.	.
11784	1226	320	1	1300	1650	45	5	.	.
11784	1230	.	.	.	.	.	.	6600	12.5
11784	1233	185	1	.	.	.	.	.	.
11784	1233	284	2	.	.	.	.	.	.
11784	1241	395	1	1200	1700	40	5	.	.
11784	1247	55	1	.	.	.	.	.	.
11784	1247	46	6	.	.	.	.	.	.
11784	1255	186	1	.	.	.	.	.	.
11784	1257	104	1	1300	1750	40	5	.	.
11784	1257	28	6	.	.	.	.	.	.
11784	1315	300	2	.	.	.	.	.	.

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11784	1335	349	3	1650	1200	40	5	.	.
11784	1340	49	1	.	.	.	.	.	.
11784	1342	348	1	1450	1550	.	.		
11784	1349	422	1	.	.	.	.	.	.
11784	1354	35	1	.	.	.	.	.	.
11784	1354	78	2	.	.	.	.	.	.
11784	1358	291	1	1300	1700	40	5	.	.
11784	1405	293	1	.	.	.	.	.	.
11784	1413	146	1	1300	1600	40	5	.	.
11784	1413	367	4	.	.	.	.	.	.
11784	1424	.	.	1450	1580	35	5	.	.
11784	1428	156	1	.	.	.	.	.	.
11784	1431	173	1	.	.	.	.	.	.
11784	1438	647	1	.	.	.	.	.	.
11784	1504	133	1	.	.	.	.	.	.
11784	1506	303	3	.	.	.	.	.	.
11784	1511	121	1	.	.	.	.	.	.
11784	1513	250	1	1550	1500	35	4.5	.	.
11784	1521	82	1	.	.	.	.	.	.
11784	1526	77	1	1450	1500	33	5	.	.
11784	1532	316	1	.	.	.	.	.	.
11784	1535	314	1	1450	1750	33	5	.	.
11784	1542	460	1	1400	1700	33	5	.	.
11784	1545	533.5	1	.	.	.	.	.	.
11884	1138	269	1	1200	300	50	5	.	.
11884	1143	199	1	.	.	.	.	.	.
11884	1146	226	2	.	.	.	.	.	.
11884	1146	110	1	.	.	.	.	.	.
11884	1151	71	4	.	.	.	.	.	.
11884	1151	230	3	.	.	.	.	.	.
11884	1158	395	1	.	.	.	.	.	.
11884	1201	178	1	1550	750	50	5	.	.
11884	1204	172	1	.	.	.	.	.	.
11884	1206	139	1	.	.	.	.	.	.
11884	1210	209	1	.	.	.	.	.	.
11884	1214	176	1	.	.	.	.	.	.
11884	1219	184	1	.	.	.	.	.	.
11884	1224	205	1	.	.	.	.	.	.
11884	1227	225	1	.	.	.	.	.	.
11884	1235	210	1	1600	1050	50	5	.	.
11884	1242	210	1	.	.	.	.	.	.
11884	1246	226	1	.	.	.	.	.	.
11884	1251	338	1	.	.	.	.	.	.
11884	1258	622	2	.	.	.	.	.	.
11884	1309	.	.	.	. .	.	.	5200	12.5
11884	1312	222	1	1430	1420	47	5	.	.
11884	1317	237	1	.	.	.	.	.	.
11884	1320	81	1	.	.	.	.	.	.
11884	1324	240	1	.	.	.	.	.	.
11884	1329	107	1	.	.	.	.	.	.
11884	1329	373	4	.	.	.	.	.	.
11884	1334	69	1	.	.	.	.	.	.
11884	1340	243	1	.	.	.	.	.	.
11884	1345	583	2	.	.	.	.	.	.
11884	1349	151	1	1250	1650	45	5	.	.
11884	1355	169	1	.	.	.	.	.	.

PLANT TWO DATA

11884	1355	66	5	.	.	.	.	.	.
11884	1359	176	1	.	.	.	.	.	.
11884	1439	310	3	1600	1000	.	.	.	.
11884	1443	432	3	.	.	.	.	.	.
11884	1446	627	3	1450	1800	50	4	.	.
11884	1455	295	3	.	.	.	.	.	.
11884	1455	180	2	.	.	.	.	.	.
11884	1510	247	1	1400	1800	60	5	.	.
11884	1517	93	1	.	.	.	.	.	.
11884	1523	151	1	1600	1250	60	5	.	.
11884	1529	378	1	.	.	.	.	.	.
11884	1535	125	1	.	.	.	.	.	.
11884	1539	359	1	1600	1300	40	3.5	.	.
11884	1542	28	1	.	.	.	.	.	.
11884	1546	148	1	.	.	.	.	.	.
11884	1550	80	1	.	.	.	.	.	.
11884	1559	440	3	.	.	.	.	.	.
11884	1559	35	5	.	.	.	.	.	.
11884	1603	435	3	1550	1700	60	3.5	.	.
11884	1610	230	1	.	.	.	.	.	.
11884	1800	700	3	1600	1100	60	3.5	.	.
11884	1807	700	3	1730	1060	60	3.5	.	.
11884	1813	325	1	.	.	.	.	.	.
11884	1826	325	1	.	.	.	.	.	.
11884	1832	707	1	.	1600	.	.	.	.
11884	1836	280.5	1	1350	1700	.	.	.	.
11884	1845	327	4	1450	1650	.	.	.	.
11884	1853	.	.	.	.	.	.	.	.
11884	1855	84	1	1420	1650	.	.	4500	11
11884	1855	37.5	5	.	.	.	.	.	.
11884	1902	174	1	.	.	.	.	.	.
11884	1904	308	1	1400	1520	60	3.5	.	.
11884	1904	34.5	5	.	.	.	.	.	.
11884	1915	.	.	1500	1150	60	3.5	.	.
11884	1939	112	1	.	.	.	.	.	.
11884	1943	783	1	.	.	.	.	.	.
11884	1943	829	3	.	.	.	.	.	.
11884	1949	333	4	.	1450	.	.	.	.
11884	1959	330	1	.	.	.	.	.	.
11884	2005	202	4	.	.	.	.	.	.
11884	2017	.	.	1600	1250	.	.	.	.
11984	925	245	1	.	.	.	.	.	.
11984	925	186	3	.	.	.	.	.	.
11984	940	255	1	.	.	.	.	.	.
11984	947	242	1	.	.	.	.	.	.
11984	950	312	1	.	.	.	.	.	.
11984	956	68	1	.	.	.	.	.	.
11984	958	723	3	.	.	.	.	.	.
11984	1002	466	1	.	.	.	.	.	.
11984	1004	278	2	.	.	.	.	.	.
11984	1004	211	1	.	.	.	.	.	.
11984	1012	254	3	.	.	.	.	.	.
11984	1014	270	3	.	.	.	.	.	.
11984	1019	207	1	.	.	.	.	.	.
11984	1024	271	1	.	.	.	.	.	.
11984	1026	.	.	1200	1500	10	5	.	.

```
PLANT TWO DATA

  11984   1031   172   1     .      .      .     .     .      .
  11984   1038   330   1     .      .      .     .     .      .
  11984   1041   108   1     .      .      .     .     .      .
  11984   1048    79   1   1300   1400    50     5     .      .
  11984   1050   298   1     .      .      .     .     .      .
  11984   1052   194   1     .      .      .     .     .      .
  11984   1054   274   1   1300   1440    50     5     .      .
  11984   1059     .   .   1200   1620    50     5     .      .
  11984   1102     .   .     .      .      .     .   8000   10.5
  11984   1107     .   .   1280   1310    50     5     .      .
  11984   1111     .   .   1500   1300     .     .     .      .
  11984   1117     .   .   1610   1040     .     .     .      .
  11984   1118   376   1     .      .      .     .     .      .
  11984   1122   230   1     .      .      .     .     .      .
  11984   1127   278   1   1400   1050    60     5     .      .
  11984   1129     .   .   1300   1280     .     .     .      .
  11984   1131   397   4     .      .      .     .     .      .
  11984   1133     .   .     .      .      .     .   7600      9
  11984   1136   590   1     .      .      .     .     .      .
  11984   1137     .   .   1260   1570     .     .     .      .
  11984   1142   878   1   1280   1350    60     5     .      .
  11984   1147   601   1     .      .      .     .     .      .
  11984   1157     .   .   1140   1750     .     .     .      .
  11984   1158   376   1     .      .      .     .     .      .
  11984   1158   394   4     .      .      .     .     .      .
  11984   1202     .   .   1100   1820     6     5     .      .
  11984   1206     .   .   1180   1700     .     .   7400     13
  11984   1207     .   .     .      .      .     .   7400     13
  11984   1211   312   4     .      .      .     .     .      .
  11984   1213     .   .   1130   1770     6     5     .      .
  11984   1220   271   1     .      .      .     .     .      .
  11984   1225    85   1     .      .      .     .     .      .
  11984   1225   208   2     .      .      .     .     .      .
  11984   1229     .   .   1140   1710     6     5     .      .
  11984   1231   315   2     .      .      .     .     .      .
  11984   1231   112   1     .      .      .     .     .      .
  11984   1237     .   .   1230   1680     6     5     .      .
  11984   1241    24   5     .      .      .     .     .      .
  11984   1244   365   1     .      .      .     .     .      .
  11984   1255     .   .   1270   1440    60     5     .      .
  11984   1256   349   3     .      .      .     .     .      .
  11984   1255    90   1     .      .      .     .     .      .
  11984   1309     .   .   1300   1240    60     5     .      .
  11984   1310   200   1     .      .      .     .     .      .
  11984   1315   211   1     .      .      .     .     .      .
  11984   1320   297   1     .      .      .     .     .      .
  11984   1330     .   .   1220   1460    60     5     .      .
  11984   1337   188   1     .      .      .     .     .      .
  11984   1337   240   3     .      .      .     .     .      .
  11984   1337   392   4     .      .      .     .     .      .
  11984   1342    52   5     .      .      .     .     .      .
  11984   1354   704   1   1175   1720     9     5     .      .
  11984   1355     .   .   1200   1800     .     .     .      .
  11984   1403   364   1     .      .      .     .     .      .
  11984   1409   101   1     .      .      .     .     .      .
  11984   1409   303   2     .      .      .     .     .      .
```

PLANT TWO DATA

11984	1419	251	1	.	.	.	.	.	.
11984	1425	.	.	1400	1650	.	.	.	.
11984	1427	105	1	.	.	.	.	.	.
11984	1428	184	1	1400	1630	60	5	.	.
11984	1431	.	.	.	.	.	.	7200	13
11984	1433	.	.	1400	1720	60	5	.	.
11984	1437	.	.	1360	1620	.	.	.	.
11984	1441	.	.	1420	1550	60	5	.	.
11984	1448	.	.	1500	1260	.	.	.	.
11984	1553	201	1	1870	630	60	.	.	.
11984	1557	200	1	1500	870	.	.	.	.
11984	1602	182	1	1750	1000	.	.	.	.
11984	1603	50	1	1710	1070	60	5	.	.
11984	1607	.	.	1710	1000	.	.	.	.
11984	1610	514	3	.	.	.	.	.	.
11984	1610	243	1	1600	1270	60	5	.	.
11984	1616	.	.	1550	1310	.	.	.	.
11984	1619	.	.	1570	1220	.	.	.	.
11984	1623	528	1	1650	1200	.	.	.	.
11984	1630	.	.	1700	1200	.	.	.	.
11984	1633	519	3	1800	1130	60	5	.	.
11984	1634	.	.	1500	1570	.	.	.	.
11984	1641	.	.	1430	1350	.	.	.	.
11984	1643	366	4	.	.	.	.	.	.
11984	1643	308	1	.	.	.	.	.	.
11984	1648	304	2	.	.	.	.	.	.
11984	1715	265	1	.	.	.	.	.	.
11984	1718	.	.	1700	1000	.	.	.	.
11984	1723	175	1	1730	1180	.	.	.	.
11984	1726	482	1	.	.	.	.	.	.
11984	1730	.	.	1390	1640	60	5	.	.
11984	1736	.	.	1340	1350	.	.	.	.
11984	1741	348	4	.	.	.	.	.	.
11984	1741	55	1	.	.	.	.	.	.
11984	1742	.	.	1340	1500	60	5	.	.
11984	1748	.	.	1350	1500	60	5	.	.
11984	1749	154	1	.	.	.	.	.	.
11984	1750	.	.	1340	1440	.	.	.	.
11984	1753	.	.	.	.	.	.	7000	13
11984	1754	45	1	.	.	.	.	.	.
11984	1755	255	3	1300	1650	.	.	.	.
11984	1755	133	1	.	.	.	.	.	.
11984	1803	.	.	1350	1620	.	.	.	.
11984	1807	416	4	.	.	.	.	.	.
11984	1807	29	6	.	.	.	.	.	.
11984	1813	.	.	1390	1470	.	.	.	.
11984	1816	.	.	1390	1520	.	.	.	.
11984	1817	67	1	.	.	.	.	.	.
11984	1817	33	6	.	.	.	.	.	.
11984	1822	224	3	.	.	.	.	.	.
11984	1822	47	1	.	.	.	.	.	.
11984	1826	.	.	1330	1340	.	.	.	.
11984	1828	.	.	1420	1480	.	.	.	.
11984	1832	103	1	.	.	.	.	.	.
11984	1838	.	.	1450	1400	.	.	.	.
11984	1840	307	4	.	.	.	.	.	.

PLANT TWO DATA

11984	1840	92	1	.	.	.	.	.	.
11984	1843	.	.	1410	1160	.	.	.	.
11984	1848	119	1	1420	1130	.	.	.	.
11984	1853	90	1	1340	940	.	.	.	.
11984	1856	.	.	.	.	.	.	4000	12
111284	946	302	1	.	.	.	.	.	.
111284	956	.	.	1410	1120	.	.	.	.
111284	1003	410	1	.	.	.	.	.	.
111284	1015	260	1	.	.	.	.	.	.
111284	1020	288	1	.	.	.	.	.	.
111284	1022	270	1	.	.	.	.	.	.
111284	1022	740	3	.	.	.	.	.	.
111284	1024	.	.	1590	1300	.	.	.	.
111284	1029	165	1	.	.	.	.	.	.
111284	1035	201	1	.	.	.	.	.	.
111284	1036	.	.	1400	1280	.	.	.	.
111284	1040	.	.	1500	1300	56	.	.	.
111284	1042	593	3	.	.	.	.	.	.
111284	1042	95	1	.	.	.	.	.	.
111284	1045	401	4	1230	1650	.	.	.	.
111284	1050	614	1	.	.	.	.	8000	12
111284	1053	.	.	1230	1610	.	.	.	.
111284	1059	.	.	1190	1600	6	.	.	.
111284	1101	.	.	1200	1530	.	.	.	.
111284	1103	.	.	1230	1390	.	.	.	.
111284	1107	.	.	1230	1310	.	.	.	.
111284	1108	265	1	1220	1750	.	.	.	.
111284	1108	36	5	.	.	.	.	.	.
111284	1110	.	.	1190	1710	.	.	.	.
111284	1113	.	.	1220	1500	.	.	.	.
111284	1117	239	1	1250	1300	.	.	.	.
111284	1122	98	1	.	.	.	.	.	.
111284	1131	.	.	1250	1300	58	.	.	.
111284	1140	445	1	1320	1150	58	6	.	.
111284	1140	30	5	.	.	.	.	.	.
111284	1142	321	1	.	.	.	.	.	.
111284	1143	.	.	1250	1200	.	.	.	.
111284	1145	.	.	1250	1590	58	6	.	.
111284	1147	.	.	1240	1510	58	6	.	.
111284	1150	.	.	.	.	.	.	7800	12
111284	1155	303	4	.	.	.	.	.	.
111284	1155	35	6	.	.	.	.	.	.
111284	1200	167	1	.	.	.	.	.	.
111284	1200	313	4	.	.	.	.	.	.
111284	1202	.	.	1300	1450	.	.	.	.
111284	1207	.	.	1270	1400	.	.	.	.
111284	1209	536	1	.	.	.	.	.	.
111284	1214	250	1	.	.	.	.	.	.
111284	1214	394	4	1290	1610	.	.	.	.
111284	1223	.	.	1250	1800	.	.	.	.
111284	1225	.	.	.	.	.	.	8000	12.6
111284	1300	490	1	.	.	.	.	.	.
111284	1302	.	.	1420	1510	.	.	.	.
111284	1307	115	1	.	.	.	.	.	.
111284	1310	.	.	1600	1120	.	.	.	.
111284	1313	743	1	1590	1270	.	.	.	.

PLANT TWO DATA

111284	1315	403	1	.	.	.	.	.	.
111284	1315	28	6	.	.	.	.	.	.
111284	1318	.	.	1700	1270	.	.	.	.
111284	1330	192	1	.	.	.	.	.	.
111284	1335	.	.	.	.	.	.	80000	12
111284	1342	903	1	.	.	.	.	.	.
111284	1342	24	5	1520	1350	60	.	.	.
111284	1342	116	4	.	.	.	.	.	.
111284	1347	295	3	.	.	.	.	.	.
111284	1350	.	.	1450	1550	60	.	.	.
111284	1353	114	1	.	.	.	.	.	.
111284	1354	.	.	1270	1790	.	.	.	.
111284	1359	.	.	1300	1600	.	.	.	.
111284	1405	.	.	1420	1300	.	.	7800	12.2
111284	1407	563	1	.	.	.	.	.	.
111284	1407	29	6	.	.	.	.	.	.
111284	1408	55	1	.	.	.	.	.	.
111284	1415	517	1	1450	1400	.	.	.	.
111284	1421	750	1	1420	1370	60	.	.	.
111284	1421	29	5	.	.	.	.	.	.
111284	1426	31	6	.	.	.	.	.	.
111284	1426	105	1	.	.	.	.	.	.
111284	1426	432	3	.	.	.	.	.	.
111284	1435	.	.	1400	1400	.	.	.	.
111284	1440	.	.	1320	1400	.	.	.	.
111284	1444	.	.	1400	1000	.	.	.	.
111284	1447	.	.	1400	1250	.	.	.	.
111284	1448	.	.	1370	1250	.	.	.	.
111284	1450	.	.	1260	1370	.	.	.	.
111284	1500	.	.	.	.	.	.	7700	11
111284	1501	.	.	1150	1400	.	.	.	.
111284	1505	.	.	1170	1300	.	.	.	.

plant two oil usage data

date	beginning time	ending time	oil usage
11884	1319	1720	31.1
11884	1720	1742	3.2
11884	1742	1803	3.4
11884	1803	1853	6.3
11884	1853	1858	1.3
11884	1858	1934	5.5
11884	1934	1955	3.5
11884	1955	2020	3.6
11984	1005	1035	4.4
11984	1035	1100	3.9
11984	1100	1109	1.5
11984	1109	1118	1.6
11984	1118	1130	1.9
11984	1130	1141	1.3
11984	1141	1200	1.4
11984	1200	1217	0
11984	1217	1256	2
11984	1256	1311	1.7
11984	1311	1331	0
11984	1331	1427	6.3
11984	1427	1451	2.2
11984	1451	1609	13.2
11984	1609	1717	10.9
11984	1717	1738	3.8
11984	1738	1808	3.5
11984	1808	1823	2.1
11984	1823	1849	2.8
111284	1021	1032	2.4
111284	1032	1045	2.1
111284	1045	1058	1.7
111284	1058	1111	1.6
111284	1111	1124	2.3
111284	1124	1137	2.3
111284	1137	1146	1.3
111284	1146	1158	1.6
111284	1158	1210	2.2
111284	1210	1223	1.8
111284	1223	1305	8.5
111284	1305	1320	2.6
111284	1320	1331	2.2
111284	1331	1346	2.7
111284	1346	1400	1.3
111284	1400	1415	2.6
111284	1415	1428	2.6
111284	1428	1442	2.5
111284	1442	1501	3.1

APPENDIX C
SAMPLE SHIPMENT LETTER

ADIAN
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November 13
~~October 25~~, 1984

. S. EPA Toxicant Analysis Center
uilding 1105
ay St. Louis, MS 39529

ttention: Danny McDaniel

ubject: Tier 4 - Analysis Instructions

ear Sir:

The objective of this letter is to clarify instructions and prior- ities for individual samples from specific Tier 4 combustion sites. his instruction letter is No. 2 and pertains to EPA Site No. 02 at avport, MN.

The Episode No. is 2493, and SCC numbers assigned to this site were umbers DQ000201 through DQ000224.

SCC numbers DQ000201 through DQ000206 have been assigned to Troika or internal QA/QC purposes. All remaining numbers have been assigned o samples as described below.

The sample shipment for EPA Site No. 02 consists of 3 boxes ontaining X 39 samples.

Please note that the container numbering scheme used for the odified Method 5 (MM5) samples for EPA site 02 is different than that sed for EPA site 01. The change in the numbering scheme for EPA site 2 resulted from two individual interpretations of the ASTM protocol nd was not noticed in sufficient time to re-label all of the MM5 amples. The scheme used at EPA site 02 will be used at all future er 4 test sites.

Instructions for extraction and analysis follow.

The following samples require IMMEDIATE EXTRACTION and analysis (Priority #1 samples).

Radian Run # 02-MM5-01
(Total of 6 train components)

SCC #	Container	Fraction
DQ000207	1	Filter
DQ000207	6	XAD Module
DQ000207	2	Probe Rinse
DQ000207	3	Back Half / Coil Rinse
DQ000207	4	Condensate
DQ000207	5	Impinger Solution

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Radian Run # 02-MM5-02
(Total of 6 train components)

SCC #	Container	Fraction
DQ000211	1	Filter
DQ000211	6	XAD Module
DQ000211	2	Probe Rinse
DQ000211	3	Back Half / Coil Rinse
DQ000211	4	Condensate
DQ000211	5	Impinger Solution

Radian Run # 02-MM5-Blank
(Total of 6 train components)

SCC #	Container	Fraction
DQ000212	1	Filter
DQ000212	6	XAD Module
DQ000212	2	Probe Rinse
DQ000212	3	Back Half / Coil Rinse
DQ000212	4	Condensate
DQ000212	5	Impinger Solution

Radian Run # 02-MM5-03
(Total of 7 train components)

SCC #	Container	Fraction
DQ000219	1	Filter A
DQ000219	1	Filter B
DQ000219	6	XAD Module
DQ000219	2	Probe Rinse
DQ000219	3	Back Half / Coil Rinse
DQ000219	4	Condensate
DQ000219	5	Impinger Solution

Radian Run # 02-MM5-04
(Total of 6 train components)

SCC #	Container	Fraction
DQ000213	1	Filter
DQ000213	6	XAD Module
DQ000213	2	Probe Rinse
DQ000213	3	Back Half / Coil Rinse
DQ000213	4	Condensate
DQ000213	5	Impinger Solution

Bottom Ash - Process Sample

SCC #	Sample
DQ000210	Ash
DQ000222	Ash
DQ000224	Ash
DQ000217	Ash
DQ000218	Ash

The following Priority 2# samples should be held for analysis pending the results of Priority #1 analysis.

SCC #	Container	Fraction
DQ000214	1	Probe Rinse
DQ000214	2	XAD Module
DQ000214	3	Condensate

7. All Remaining Priority #2 and all Priority #3 samples for this site will be archived at Radian pending the results of Priority #2 analyses. These include the following:

SCC #	Sample
DQ000208	Waste feed composite
DQ000215	Waste feed composite
DQ000220	Waste feed composite
DQ000209	Fuel oil
DQ000221	Fuel oil
DQ000223	Fuel oil
DQ000216	Soils

If there are any questions concerning this sample shipment, please contact either Gary Henry, Mike Palazzolo, or Andrew Miles at Radian Corporation (919) 541-9100.

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Sincerely,

Mike Palazzolo

TEST TEAM LEADER

APPENDIX D
DIOXIN/FURAN ANALYTICAL DATA FOR GASEOUS SAMPLES

TABLE D-1. DIOXIN/FURAN ANALYTICAL DATA FOR MM5 TRAINS

Isomer/Homologue	Amount Detected, Picograms per Sample Train Run 01	Run 02	Run 03	Run 04
Dioxins				
2378 TCDD	2,000	2,000	7,000	5,000
Other TCDD	33,000	38,000	124,000	83,000
Penta CDD	50,000	55,000	155,000	113,000
Hexa CDD	98,000	81,000	187,000	152,000
Hepta CDD	117,000	98,000	239,000	312,000
Octa CDD	48,000	43,000	84,000	56,000
Total PCDD	348,000	317,000	796,000	721,000
Furans				
2378 TCDF	11,000	9,600	31,000	22,000
Other TCDF	337,000	309,400	692,000	670,000
Penta CDF	351,000	288,000	681,000	739,000
Hexa CDF	560,000	207,000	629,000	696,000
Hepta CDF	390,000	215,000	426,000	597,000
Octa CDF	53,000	39,000	87,000	61,000
Total PCDF	1,702,000	1,068,000	2,546,000	2,785,000

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APPENDIX E
RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA

E-1

Run-Specific Dioxin/Furan Emissions Data
(As-measured Concentrations)

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TABLE E-1. DIOXIN/FURAN EMISSIONS DATA FOR RUN 1, SITE ISW-A

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	4.12E-01(N/A)	3.08E-02(N/A)	6.18E+00
Other TCDD	6.80E+00(N/A)	5.08E-01(N/A)	1.02E+02
Penta-CDD	1.03E+01(N/A)	6.97E-01(N/A)	1.54E+02
Hexa-CDD	2.02E+01(N/A)	1.24E+00(N/A)	3.03E+02
Hepta-CDD	2.41E+01(N/A)	1.37E+00(N/A)	3.61E+02
Octa-CDD	9.90E+00(N/A)	5.18E-01(N/A)	1.48E+02
Total PCDD	7.18E+01	4.36E+00	1.07E+03
FURANS			
2378 TCDF	2.27E+00(N/A)	1.78E-01(N/A)	3.40E+01
Other TCDF	6.95E+01(N/A)	5.46E+00(N/A)	1.04E+03
Penta-CDF	7.24E+01(N/A)	5.12E+00(N/A)	1.08E+03
Hexa-CDF	1.15E+02(N/A)	7.41E+00(N/A)	1.73E+03
Hepta-CDF	6.37E+01(N/A)	3.75E+00(N/A)	9.54E+02
Octa-CDF	1.09E+01(N/A)	5.92E-01(N/A)	1.64E+02
Total PCDF	3.34E+02	2.25E+01	5.01E+03

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

N/A = detection limits not applicable. QA samples indicate method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt parts per trillion, dry volume basis
2200 operating hours per year

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TABLE E-2 DIOXIN/FURAN EMISSIONS DATA FOR RUN 2, SITE 2

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	5.39E-01(N/A)	4.03E-02(N/A)	8.62E+00
Other TCDD	1.02E+01(N/A)	7.65E-01(N/A)	1.64E+02
Penta-CDD	1.48E+01(N/A)	1.00E+00(N/A)	2.37E+02
Hexa-CDD	2.18E+01(N/A)	1.34E+00(N/A)	3.49E+02
Hepta-CDD	2.64E+01(N/A)	1.50E+00(N/A)	4.23E+02
Octa-CDD	1.16E+01(N/A)	6.06E-01(N/A)	1.85E+02
Total PCDD	8.54E+01	5.25E+00	1.37E+03
FURANS			
2378 TCDF	2.59E+00(N/A)	2.03E-01(N/A)	4.14E+01
Other TCDF	8.34E+01(N/A)	6.56E+00(N/A)	1.33E+03
Penta-CDF	7.76E+01(N/A)	5.49E+00(N/A)	1.24E+03
Hexa-CDF	5.58E+01(N/A)	3.58E+00(N/A)	8.92E+02
Hepta-CDF	5.80E+01(N/A)	3.41E+00(N/A)	9.27E+02
Octa-CDF	1.05E+01(N/A)	5.70E-01(N/A)	1.68E+02
Total PCDF	2.88E+02	1.98E+01	4.60E+03

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

N/A = detection limits not applicable. QA samples indicate method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt parts per trillion, dry volume basis
2200 operating hours per year

TABLE E-3. DIOXIN/FURAN EMISSIONS DATA FOR RUN 3, SITE ISW-A

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	1.47E+00(N/A)	1.10E-01(N/A)	2.00E+01
Other TCDD	2.61E+01(N/A)	1.95E+00(N/A)	3.55E+02
Penta-CDD	3.26E+01(N/A)	2.21E+00(N/A)	4.44E+02
Hexa-CDD	3.94E+01(N/A)	2.42E+00(N/A)	5.36E+02
Hepta-CDD	5.03E+01(N/A)	2.85E+00(N/A)	6.85E+02
Octa-CDD	1.77E+01(N/A)	9.25E-01(N/A)	2.41E+02
Total PCDD	1.68E+02	1.05E+01	2.28E+03
FURANS			
2378 TCDF	6.53E+00(N/A)	5.13E-01(N/A)	8.88E+01
Other TCDF	1.46E+02(N/A)	1.15E+01(N/A)	1.98E+03
Penta-CDF	1.43E+02(N/A)	1.01E+01(N/A)	1.95E+03
Hexa-CDF	1.32E+02(N/A)	8.49E+00(N/A)	1.80E+03
Hepta-CDF	8.97E+01(N/A)	5.27E+00(N/A)	1.22E+03
Octa-CDF	1.83E+01(N/A)	9.92E-01(N/A)	2.49E+02
Total PCDF	5.36E+02	3.69E+01	7.29E+03

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

N/A = detection limits not applicable. QA samples indicate method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt parts per trillion, dry volume basis
2200 operating hours per year

TABLE E-4. DIOXIN/FURAN EMISSIONS DATA FOR RUN 4, SITE ISW-A

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	1.01E+00(N/A)	7.58E-02(N/A)	1.44E+01
Other TCDD	1.68E+01(N/A)	1.26E+00(N/A)	2.39E+02
Penta-CDD	2.29E+01(N/A)	1.55E+00(N/A)	3.26E+02
Hexa-CDD	3.08E+01(N/A)	1.90E+00(N/A)	4.38E+02
Hepta-CDD	6.33E+01(N/A)	3.58E+00(N/A)	9.00E+02
Octa-CDD	1.14E+01(N/A)	5.94E-01(N/A)	1.61E+02
Total PCDD	1.46E+02	8.96E+00	2.08E+03
FURANS			
2378 TCDF	4.46E+00(N/A)	3.51E-01(N/A)	6.34E+01
Other TCDF	1.36E+02(N/A)	1.07E+01(N/A)	1.93E+03
Penta-CDF	1.50E+02(N/A)	1.06E+01(N/A)	2.13E+03
Hexa-CDF	1.41E+02(N/A)	9.06E+00(N/A)	2.01E+03
Hepta-CDF	1.21E+02(N/A)	7.12E+00(N/A)	1.72E+03
Octa-CDF	1.24E+01(N/A)	6.70E-01(N/A)	1.76E+02
Total PCDF	5.65E+02	3.85E+01	8.03E+03

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

N/A = detection limits not applicable. QA samples indicate method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt parts per trillion, dry volume basis
2200 operating hours per year

E-2

Run-Specific Dioxin/Furan Emissions Data
(Concentrations Corrected to 3 Percent Oxygen)

TABLE E-5. DIOXIN/FURAN EMISSIONS DATA FOR RUN 1, SITE ISW-A
Concentrations Corrected to 3% Oxygen

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	2.17E+00(N/A)	1.62E-01(N/A)	6.18E+00
Other TCDD	3.58E+01(N/A)	2.68E+00(N/A)	1.02E+02
Penta-CDD	5.43E+01(N/A)	3.67E+00(N/A)	1.54E+02
Hexa-CDD	1.06E+02(N/A)	6.54E+00(N/A)	3.03E+02
Hepta-CDD	1.27E+02(N/A)	7.19E+00(N/A)	3.61E+02
Octa-CDD	5.21E+01(N/A)	2.72E+00(N/A)	1.48E+02
Total PCDD	3.78E+02	2.30E+01	1.07E+03
FURANS			
2378 TCDF	1.19E+01(N/A)	9.38E-01(N/A)	3.40E+01
Other TCDF	3.66E+02(N/A)	2.87E+01(N/A)	1.04E+03
Penta-CDF	3.81E+02(N/A)	2.69E+01(N/A)	1.08E+03
Hexa-CDF	6.08E+02(N/A)	3.90E+01(N/A)	1.73E+03
Hepta-CDF	3.35E+02(N/A)	1.97E+01(N/A)	9.54E+02
Octa-CDF	5.75E+01(N/A)	3.12E+00(N/A)	1.64E+02
Total PCDF	1.76E+03	1.18E+02	5.01E+03

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

N/A = detection limits not applicable. QA samples indicate method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt parts per trillion, dry volume basis
2200 operating hours per year

TABLE E-6 DIOXIN/FURAN EMISSIONS DATA FOR RUN 2, SITE 2
Concentrations Corrected to 3% Oxygen

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	3.45E+00(N/A)	2.58E-01(N/A)	8.62E+00
Other TCDD	6.56E+01(N/A)	4.90E+00(N/A)	1.64E+02
Penta-CDD	9.50E+01(N/A)	6.42E+00(N/A)	2.37E+02
Hexa-CDD	1.40E+02(N/A)	8.60E+00(N/A)	3.49E+02
Hepta-CDD	1.69E+02(N/A)	9.58E+00(N/A)	4.23E+02
Octa-CDD	7.42E+01(N/A)	3.88E+00(N/A)	1.85E+02
Total PCDD	5.47E+02	3.36E+01	1.37E+03
FURANS			
2378 TCDF	1.66E+01(N/A)	1.30E+00(N/A)	4.14E+01
Other TCDF	5.34E+02(N/A)	4.20E+01(N/A)	1.33E+03
Penta-CDF	4.97E+02(N/A)	3.52E+01(N/A)	1.24E+03
Hexa-CDF	3.57E+02(N/A)	2.29E+01(N/A)	8.92E+02
Hepta-CDF	3.71E+02(N/A)	2.18E+01(N/A)	9.27E+02
Octa-CDF	6.73E+01(N/A)	3.65E+00(N/A)	1.68E+02
Total PCDF	1.84E+03	1.27E+02	4.60E+03

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

N/A = detection limits not applicable. QA samples indicate method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt parts per trillion, dry volume basis
2200 operating hours per year

TABLE E-7. DIOXIN/FURAN EMISSIONS DATA FOR RUN 3, SITE ISW-A
Concentrations Corrected to 3% Oxygen

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	4.89E+00(N/A)	3.66E-01(N/A)	2.00E+01
Other TCDD	8.67E+01(N/A)	6.48E+00(N/A)	3.55E+02
Penta-CDD	1.08E+02(N/A)	7.32E+00(N/A)	4.44E+02
Hexa-CDD	1.31E+02(N/A)	8.04E+00(N/A)	5.36E+02
Hepta-CDD	1.67E+02(N/A)	9.46E+00(N/A)	6.85E+02
Octa-CDD	5.87E+01(N/A)	3.07E+00(N/A)	2.41E+02
Total PCDD	5.57E+02	3.47E+01	2.28E+03
FURANS			
2378 TCDF	2.17E+01(N/A)	1.70E+00(N/A)	8.88E+01
Other TCDF	4.84E+02(N/A)	3.80E+01(N/A)	1.98E+03
Penta-CDF	4.76E+02(N/A)	3.37E+01(N/A)	1.95E+03
Hexa-CDF	4.40E+02(N/A)	2.82E+01(N/A)	1.80E+03
Hepta-CDF	2.98E+02(N/A)	1.75E+01(N/A)	1.22E+03
Octa-CDF	6.08E+01(N/A)	3.30E+00(N/A)	2.49E+02
Total PCDF	1.78E+03	1.22E+02	7.29E+03

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

N/A = detection limits not applicable. QA samples indicate method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt parts per trillion, dry volume basis
2200 operating hours per year

TABLE E-8. DIOXIN/FURAN EMISSIONS DATA FOR RUN 4, SITE ISW-A
Concentrations Corrected to 3% Oxygen

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	6.52E+00(N/A)	4.87E-01(N/A)	1.44E+01
Other TCDD	1.08E+02(N/A)	8.09E+00(N/A)	2.39E+02
Penta-CDD	1.47E+02(N/A)	9.96E+00(N/A)	3.26E+02
Hexa-CDD	1.98E+02(N/A)	1.22E+01(N/A)	4.38E+02
Hepta-CDD	4.07E+02(N/A)	2.30E+01(N/A)	9.00E+02
Octa-CDD	7.30E+01(N/A)	3.82E+00(N/A)	1.61E+02
Total PCDD	9.40E+02	5.76E+01	2.08E+03
FURANS			
2378 TCDF	2.87E+01(N/A)	2.26E+00(N/A)	6.34E+01
Other TCDF	8.74E+02(N/A)	6.87E+01(N/A)	1.93E+03
Penta-CDF	9.64E+02(N/A)	6.82E+01(N/A)	2.13E+03
Hexa-CDF	9.08E+02(N/A)	5.82E+01(N/A)	2.01E+03
Hepta-CDF	7.78E+02(N/A)	4.58E+01(N/A)	1.72E+03
Octa-CDF	7.95E+01(N/A)	4.31E+00(N/A)	1.76E+02
Total PCDF	3.63E+03	2.47E+02	8.03E+03

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

N/A = detection limits not applicable. QA samples indicate method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt parts per trillion, dry volume basis
2200 operating hours per year

APPENDIX F
RUN-SPECIFIC RISK MODELING INPUT DATA

TABLE F-1. RISK MODELING PARAMETERS FOR RUN 1, SITE ISW-A

Latitude = 45 Degrees, 01 Minutes, 28 Seconds
Longitude = 92 Degrees, 46 Minutes, 40 Seconds
Stack Height (From Grade Level) = 36.6 m
Stack Diameter (ID) = 0.91 m
Flue Gas Flow Rate (Dry Standard) = 249.7 dscmm
Flue Gas Exit Temperature = 414.7 Degrees K
Flue Gas Exit Velocity (Actual) = 631 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	4.12E-01	6.18E+00	1.000	1.36E+01
Other TCDD	6.80E+00	1.02E+02	.010	2.24E+00
2378 TCDF	2.27E+00	3.40E+01	.100	7.47E+00
Other TCDF	6.95E+01	1.04E+03	.001	2.29E+00
Penta-CDD	1.03E+01	1.54E+02	.500	1.70E+02
Penta-CDF	7.24E+01	1.08E+03	.100	2.39E+02
Hexa-CDD	2.02E+01	3.03E+02	.040	2.66E+01
Hexa-CDF	1.15E+02	1.73E+03	.010	3.81E+01
Hepta-CDD	2.41E+01	3.61E+02	.001	7.95E-01
Hepta-CDF	6.37E+01	9.54E+02	.001	2.10E+00
Octa-CDD	9.90E+00	1.48E+02	.000	.00E+00
Octa-CDF	1.09E+01	1.64E+02	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				5.02E+02

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
2200 operating hours per year

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TABLE F-2 RISK MODELING PARAMETERS FOR RUN 2, SITE 2

Latitude = 45 01 28
Longitude = 92 46 40
Stack Height (From Grade Level) = 36.6 m
Stack Diameter (ID) = 0.91 m
Flue Gas Flow Rate (Dry Standard) = 266.60 dscmm
Flue Gas Exit Temperature = 431 K
Flue Gas Exit Velocity (Actual) = 700.2 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	5.39E-01	8.62E+00	1.000	1.90E+01
Other TCDD	1.02E+01	1.64E+02	.010	3.60E+00
2378 TCDF	2.59E+00	4.14E+01	.100	9.11E+00
Other TCDF	8.34E+01	1.33E+03	.001	2.93E+00
Penta-CDD	1.48E+01	2.37E+02	.500	2.61E+02
Penta-CDF	7.76E+01	1.24E+03	.100	2.73E+02
Hexa-CDD	2.18E+01	3.49E+02	.040	3.07E+01
Hexa-CDF	5.58E+01	8.92E+02	.010	1.96E+01
Hepta-CDD	2.64E+01	4.23E+02	.001	9.30E-01
Hepta-CDF	5.80E+01	9.27E+02	.001	2.04E+00
Octa-CDD	1.16E+01	1.85E+02	.000	.00E+00
Octa-CDF	1.05E+01	1.68E+02	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				6.22E+02

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
2200 operating hours per year

TABLE F-3. RISK MODELING PARAMETERS FOR RUN 3, SITE ISW-A

Latitude = 45 Degrees, 01 Minutes, 28 Seconds
Longitude = 92 Degrees, 46 Minutes, 40 Seconds
Stack Height (From Grade Level) = 36.6 m
Stack Diameter (ID) = 0.91 m
Flue Gas Flow Rate (Dry Standard) = 226.7
Flue Gas Exit Temperature = 460.2 Degrees K
Flue Gas Exit Velocity (Actual) = 643 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	1.47E+00	2.00E+01	1.000	4.41E+01
Other TCDD	2.61E+01	3.55E+02	.010	7.81E+00
2378 TCDF	6.53E+00	8.88E+01	.100	1.95E+01
Other TCDF	1.46E+02	1.98E+03	.001	4.36E+00
Penta-CDD	3.26E+01	4.44E+02	.500	4.88E+02
Penta-CDF	1.43E+02	1.95E+03	.100	4.29E+02
Hexa-CDD	3.94E+01	5.36E+02	.040	4.71E+01
Hexa-CDF	1.32E+02	1.80E+03	.010	3.96E+01
Hepta-CDD	5.03E+01	6.85E+02	.001	1.51E+00
Hepta-CDF	8.97E+01	1.22E+03	.001	2.68E+00
Octa-CDD	1.77E+01	2.41E+02	.000	.00E+00
Octa-CDF	1.83E+01	2.49E+02	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				1.08E+03

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
2200 operating hours per year

TABLE F-4. RISK MODELING PARAMETERS FOR RUN 4, SITE ISW-A

Latitude = 45 Degrees, 01 Minutes, 28 Seconds
Longitude = 92 Degrees, 46 Minutes, 40 Seconds
Stack Height (From Grade Level) = 36.6 m
Stack Diameter (ID) = 0.91 m
Flue Gas Flow Rate (Dry Standard) = 236.9 dscmm
Flue Gas Exit Temperature = 450.0 Degrees K
Flue Gas Exit Velocity (Actual) = 641 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	1.01E+00	1.44E+01	1.000	3.17E+01
Other TCDD	1.68E+01	2.39E+02	.010	5.27E+00
2378 TCDF	4.46E+00	6.34E+01	.100	1.40E+01
Other TCDF	1.36E+02	1.93E+03	.001	4.25E+00
Penta-CDD	2.29E+01	3.26E+02	.500	3.58E+02
Penta-CDF	1.50E+02	2.13E+03	.100	4.69E+02
Hexa-CDD	3.08E+01	4.38E+02	.040	3.86E+01
Hexa-CDF	1.41E+02	2.01E+03	.010	4.42E+01
Hepta-CDD	6.33E+01	9.00E+02	.001	1.98E+00
Hepta-CDF	1.21E+02	1.72E+03	.001	3.79E+00
Octa-CDD	1.14E+01	1.61E+02	.000	.00E+00
Octa-CDF	1.24E+01	1.76E+02	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				9.71E+02

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
2200 operating hours per year

APPENDIX G

RESEARCH TRIANGLE INSTITUTE (RTI)
SITE ISW-A SYSTEMS AUDIT

QUALITY ASSURANCE AUDIT FOR TIER 4 OF THE NATIONAL DIOXIN STUDY:
INDUSTRIAL INCINERATOR SITE ISW-A

by

Richard V. Crume

EPA Contract No. 68-02-3149
Work Assignment 10-1

RTI Project No. 472U-2500-48

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Research Triangle Park, NC 27711

February 1985

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1.0 SUMMARY

On November 8, 1984, Research Triangle Institute (RTI) performed a quality assurance (QA) audit of an emission test program underway at an industrial incinerator located at site designation "ISW-A." The emission test program was one of a series of tests performed by Radian Corporation for the U.S. Environmental Protection Agency (EPA). The data collected during these tests will be added to the data base supporting Tier 4 of EPA's National Dioxin Study. ("Tier 4" refers to those combustion sources having the potential to emit significant concentrations of a dioxin compound known as 2,3,7,8-tetrachlorodibenzo-p-dioxin, or 2,3,7,8-TCDD. 2,3,7,8-TCDD is a potential human carcinogen.) The audit was performed by Richard Crume, an environmental engineer with RTI. The EPA Project Officer is William Kuykendal, of the Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. A list of persons present during the audit is presented in Table 1.

The goals of the audit were to: (1) evaluate Radian Corporation's adherence to the test program's test plan and QA plan; (2) document the test procedures used; and (3) make any recommendations that could improve the quality of data collected during future tests. Overall, RTI was impressed with the test team and the quality of their work. Although on the day of the audit several process disruptions occurred, these problems were beyond the control of the Radian test team. RTI is satisfied that the data generated by the test program will be of sufficient quality to achieve the objectives of the study, provided that: (1) the analytical procedures, which will be evaluated under a separate audit, are performed correctly; and (2) the sampling procedures continue to be performed with the same level of care exhibited during the Site ISW-A tests.

RTI's audit recommendations are summarized in Table 2. These recommendations address problems which are not serious enough to invalidate the test results. However, the implementation is crucial for two reasons:

TABLE 1. LIST OF PERSONS PRESENT DURING RTI AUDIT

Name	Affiliation
Mike Palazzolo	Radian (Test Team Leader)
Dave Dayton	Radian
Lee Garcia	Radian
Gary Henry	Radian
Jim McReynolds	Radian
Dave Savia	Radian
Bob Mournigham	EPA (Cincinnati)
Richard Crume	Research Triangle Institute

TABLE 2. SUMMARY OF RECOMMENDATIONS

Modified Method 5 (MM5) Sampling Train

- Radian should mount the MM5 sampling train's XAD-condenser in a vertical position during future tests. Alternatively, Radian should explain in each test report: (1) why the condenser mounting position differs from the test protocol; and (2) what effect this is likely to have on the outcome of that particular series of tests (e.g., was all moisture observed to be carried forward into the resin).

Blank MM5 Sampling Train

- The front and back ends of the blank MM5 train should remain sealed throughout each test. The probe should be sealed with hexane-rinsed aluminum foil and the last impinger with a ground glass cap.

Ambient XAD Sampling Train

- Ordinarily the XAD resin trap associated with the ambient sampling train is kept in place between the 4-hour test runs and is not removed until the final test run at a given site is complete. The resin trap should be cooled between test runs as well as during the runs. This is especially important whenever the train is located in hot or variable-temperature environments.

HCl Sampling Train

- During the audit the HCl sampling probe broke, thereby invalidating the HCl results. More care should be taken in the future to avoid breakage of equipment.

Continuous Emission Monitors

- Calibration and quality control gases for the continuous emission monitors should test the entire sampling interface, beginning at the stack.

- Once the span check of a continuous monitor has been completed, the monitor's reading should be allowed to return to zero before challenging the meter with a quality control gas.

- If possible, Radian's continuous monitor data acquisition system should incorporate a time constant to average out positive and negative noise peaks in the monitor signal.

(continued)

TABLE 2 (continued)

- Temperature variations within the continuous monitor trailer should be minimized so that continuous monitor stability will be improved.
- Continuous monitor strip charts should be offset a positive 10% from zero to avoid negative drift.

Sample Handling, Transportation, and Storage

- The liquid level on all sample collection bottles should be marked at the time of collection.

Soil Sampling

- Soil sampling should be conducted over a wide area where potential dioxin contamination is most likely.
- Soil samples should be composited using an appropriate tool, such as a hexane-rinsed garden trowel.
- All debris (e.g., leaves and dead grass) should be cleaned from the ground before soil sampling is begun.

(1) the recommendations will help prevent potential problems from developing in the future; and (2) the recommendations will bring all test procedures into agreement with the written protocols.

2.0 INTRODUCTION

2.1 PROCESS DESCRIPTION

The process unit under study during the Site ISW-A incinerator test program was a Kelley Model 2500 waste incinerator rated at 18 MMBtu/h. This unit consists of primary and secondary combustion chambers, a waste heat boiler, and a steam turbine. Various waste materials are burned, including:

- Paint filters and dry paint,
- Paint sludge,
- Wood/plastic cutoffs,
- Wooden crate parts,
- Paper and cardboard, and
- Office and cafeteria waste.

No. 2 fuel oil is burned to help sustain combustion. Additionally, the incinerator is fed about every 10 minutes on a batch basis so that a total of approximately 1 ton of waste material is burned each hour. Emissions are ducted to a stack that stands about 30 feet above the roof of the two-story building housing the incinerator.

Four aspects of the incinerator design must be carefully considered in designing a successful emission test program. These aspects are summarized below:

- Ambient Air Damper: This damper, which is about 30 feet from the top of the stack, opens or closes as required to maintain a design draft in the secondary chamber. The amount of dilution air introduced by this damper must be considered when deciding upon the stack sampling time required to obtain a detectable concentration of the desired pollutant.
- Exhaust Fan: The ID fan, located upstream of the boiler, cuts on and off according to the demand for steam and the associated bypass of gases past the boiler. The periodic switching on and

off of this fan requires that stack isokinetic sampling rates be watched carefully.

- Ash Pushing: Several times each day ash is pushed from the bottom of the incinerator into disposal carts, causing large clouds of dust to be carried up the stack. The selection of the testing period must take into account the ash pushing schedule so that a representative number of pushes can be included in the test.
- Batch Loading of Wastes: Waste materials are loaded into the incinerator on a batch basis. This has the potential to cause variations in stack exhaust rates, making careful control of isokinetic sampling rates important.

More details concerning the incinerator design can be found in Radian Corporation's Test Plan.[1]

2.2 TEST PROGRAM DESIGN

The test program can be divided into the following categories:

- Process monitoring,
- Modified Method 5 (MM5) sampling train,
- Blank MM5 sampling train,
- Ambient MM5 sampling train,
- HCl sampling train,
- Continuous emission monitors,
- Process samples,
- Sample handling, transportation, and storage, and
- Soil sampling.

Details concerning these systems can be found in Radian Corporation's Test Plan,[1] Quality Assurance Plan,[2] and Sampling Procedures Document.[3]

The most important aspect of the test program concerns the sampling of organic compounds (including any dioxins present in the gas stream) using a MM5 sampling train. The MM5 train is similar to the EPA Method 5 train, except that a sorbent trap for the collection of vapor phase organics is included. The trap consists of separate sections for cooling the gas stream and for adsorbing the organic compounds onto Amberlite XAD-2 resin.

The setup and operation of the MM5 train are described in detail in the "ASME MM5 Sampling Methodology for Chlorinated Organics" contained in Radian's Test Plan.[1] Three test runs, each of approximately 4 hours' duration, were to be conducted at the test site.

2.3 AUDIT OBJECTIVES

The goals of the audit were to evaluate the quality of work performed by Radian Corporation, to document the test procedures used, and to make any recommendations that could improve the quality of data collected during future tests. These goals were achieved by performing two types of audit activities: systems audits and performance audits.

A systems audit consists of an onsite inspection and review of the test procedures (including any QA activities) associated with test program measurements. RTI's systems audit of the Radian test began with an evaluation of Radian's QA project plan.[2] This plan was evaluated according to the criteria presented in EPA's QAMS-005/80 guideline document and summarized in Table 3.[4] Radian's test plan was similarly evaluated, although adherence to the QAMS-005/80 criteria was not required. RTI's comments on the Radian QA and Test Plans were previously submitted.[5] [6] The systems audit continued with an onsite inspection of the Radian test program and the preparation of this report. (An onsite systems audit of Radian's analytical laboratory will also be performed in early 1985. The results of the laboratory audit will be presented in a separate report.)

The objectives of a performance audit are similar to those of a systems audit (i.e., to evaluate the quality of data likely to be generated by the test or experimental program). The performance audit differs from the systems audit in that it involves the actual measurement of critical test program parameters using standardized reference materials. RTI's performance audit of the Radian test program utilized the materials listed in Table 4. Radian, its subcontractor, and EPA's Troika Laboratories will analyze these materials and return the results to RTI for evaluation. The results, which will be useful in assessing the accuracy and precision of the measurement systems, will be discussed by RTI in a separate report.

TABLE 3. CRITICAL QUALITY ASSURANCE ELEMENTS

Project Description

- Project description
- Experimental design
- Intended use of acquired data
- Start and completion dates
- Appropriate diagrams, tables, and figures

Project Organization and Responsibility

- Organization of project
- Line of authority
- Key individuals (including quality assurance official)

Quality Assurance Objectives for Measurement Data

- Precision
- Accuracy
- Completeness
- Representativeness
- Comparability

Sampling Procedures

- Sampling site selection
- Sampling procedures
- Description of containers for sample collection, preservation, transport, and storage
- Procedures to avoid sample contamination
- Sample preservation methods and holding times
- Procedures for recording sample history, sampling conditions, and analyses to be performed

Sample Custody Records

- Preparation of reagents or supplies associated with sample
- Location and conditions where sample was taken
- Sample preservation methods
- Labeling
- Field tracking forms
- Field and laboratory sample custodians
- Laboratory custody log
- Laboratory handling, storage, and dispersement procedures

Table 3. Continued

Calibration Procedures

- Description of, or reference to, calibration procedure
- Frequency of calibration
- Calibration standards, including sources and traceability procedures

Analytical Procedures

- Analytical procedure
- Appropriateness of method

Data Reduction, Validation, and Reporting

- Data reduction scheme
- Equations to be used
- Validation procedures
- Identification and treatment of outliers

Internal Quality Control Checks

- Replicates
- Spiked samples
- Split samples
- Control charts
- Blanks
- Internal standards
- Zero and span gases
- Quality control samples
- Surrogate samples
- Reagent checks
- Calibration standards and devices

Performance and Systems Audits

- Schedule for conducting audits
- Systems to be audited
- Sources of audit materials

Procedures to Assess Data Precision, Accuracy, and Completeness

- Central tendency and dispersion
- Measures of variability
- Significance test
- Confidence limits
- Testing for outliers

Preventive Maintenance

- Schedule of maintenance tasks
- List of critical spare parts on hand

Table 3. Continued

Corrective Action

- Predetermined limits for data acceptability
- Procedures for corrective action
- Responsible individuals

Quality Assurance Reports to Management

- Frequency of reporting
- Responsible individuals
- Significant problems and recommended solutions

TABLE 4. REFERENCE MATERIALS USED TO EVALUATE THE RADIAN TEST PROGRAM

Material	Description
1. Fuel oil	Fuel oil spiked with known chloride concentration.
2. Fuel oil	Similar to Material No. 1.
3. Fuel oil	Similar to Material No. 1.
4. HCl impinger solution	HCl train impinger solution having verified chloride concentration.
5. HCl impinger solution	Similar to Material No. 4.
6. Dust sample	Dust sample having known 2,3,7,8-TCDD concentration.
7. Particulate sample	Particulate sample having known 2,3,7,8-TCDD concentration.
8. Computer data	Data to be fed into Radian's computer to examine the accuracy of the computer calculations.
9. Calibrated orifice	Used to evaluate the sampling trains' dry gas meter calibrations.

3.0 COMMENTS AND RECOMMENDATIONS

3.1 INTRODUCTION

Observations made during the audit are recorded on the checklists contained in the Appendix. These checklists were used during the audit to document the procedures used by Radian and to help identify any problem areas. RTI's observations and recommendations are discussed further in the sections below. Additionally, RTI's recommendations are summarized in Table 2 of Chapter 1.0.

3.2 PROCESS OPERATION

On the day the audit took place the sampling was interrupted several times because the incinerator was shut down. Since the shutdowns were unannounced and unexpected, the test team was unable to simultaneously cease their sampling activities. Consequently, the trains sampled a gas stream that may have been somewhat nonrepresentative of normal operation. Although the shutdowns were largely due to equipment malfunction (i.e., a broken fuel oil line and turbine blade), it appeared that a lack of diligence on the part of the incinerator operator was also a factor. One operator in particular was less diligent and less cooperative with the test team than other operators encountered during the testing.

Another process variable that presented a problem to the test team was the stack exhaust fan, which cut on and off according to steam demand. The fan presented a challenge to the sample train operators in maintaining isokinetic sampling rates.

A third process variable of concern to the test team was the ambient air intake damper, located about 30 feet from the top of the stack. The damper position, which did not vary substantially during the test run, resulted in dilution of the stack gases by roughly 50 percent. The effect of the dilution was to double (from 80 to 160 minutes) the sampling time required to detect a minimum of 1.0 ppt dioxin in the stack gases.[2] (Since the total sampling time exceeded 160 minutes, the dilution of stack gases did not present a problem in achieving the 1.0 ppt minimum detection limit goal.) Additionally, there is some risk that the gases sucked into the stack gas stream though the intake damper may have contaminated the gas stream with dioxins or other chlorinated organic compounds. However, this seems unlikely because no other organics emission sources were believed to be in the vicinity of the intake damper. (Any contaminants would be detected by the ambient MM5 sampling train, which was located close to the intake damper.)

A final troublesome process variable was the frequency at which ash was pushed from the incinerator bottom into disposal carts. Since this frequency varied with the operator, the test team had difficulty determining how many pushes represented normal operation.

The net effect of the problems noted above was to shorten the sampling period to less than the 4-hour goal and to raise questions concerning the representativeness of samples obtained.

As a result of these problems and their potential adverse effects on sample representativeness and data quality, Radian decided to extend the test program at this industrial site from three to four tests. The fourth test was intended to provide an extra set of data in the event that the data set produced by test No. 2 (i.e., the test audited by RTI) is judged in the future to be unacceptable or of poor quality. Fortunately, the problems which occurred during the RTI audit were reported to be much less significant during the other three tests at this site.

The Radian test team handled the problems discussed above in a responsible manner. Furthermore, Radian was very conscientious about taking feed material weights and recording all pertinent process operating parameters.

3.3 MODIFIED METHOD 5 SAMPLING TRAIN

The MM5 sampling train appeared to be set up and operated according to the ASME MM5 sampling methodology specified in Radian's Test Plan, with one exception: the position of the XAD trap condenser. Radian mounted the condenser in a horizontal position, although the ASME method specifies that the condenser shall be oriented vertically. The mounting of the condenser in a horizontal position is not a problem provided that all condensed liquids are carried forward into the resin by the gas stream. Although this appeared to be the case during the audit, there is no guarantee that this will always be the case during future tests. Furthermore, test results carry more credibility when the test procedure is strictly adhered to. Otherwise, all MM5 procedures specified in the Test Plan appeared to be implemented correctly.

It is recommended that Radian mount the MM5 XAD-condenser in a vertical position during future tests. Alternatively, Radian should explain in each test report: (1) why the condenser mounting position differs from the test protocol; and (2) what effect this is likely to have on the outcome of that particular series of tests (e.g., was all moisture observed to be carried forward into the resin).

3.4 BLANK MM5 SAMPLING TRAIN

The blank MM5 sampling train was located at the base of the sample train scaffolding and consisted of most of the essential elements of a standard MM5 train (i.e., the probe filter box, XAD cartridge, and impingers). The probe inlet and the final impinger outlet were capped with hexane-rinsed aluminum foil. The main discrepancy between Radian's procedure and the test protocol involved the period of time during which the train ends were capped. The test protocol implies that the train ends are to remain capped throughout the test; however, Radian was observed to remove the caps during part of the test.

An additional discrepancy between Radian's procedure and the test protocol involves the type of cap used to seal the last impinger. The test protocol specifies that a ground glass cap shall be used, whereas Radian was observed to use hexane-rinsed aluminum foil. (Radian may have intended to remove the caps during periods coinciding with the movement of the stack MM5 train from one point or one port to another point or port. Nevertheless, the procedure specified in the test protocol appears to be more appropriate.)

It is recommended that Radian allow the front and back ends of the blank MM5 train to remain sealed throughout future tests. The probe should be sealed with hexane-rinsed aluminum foil and the last impinger with a ground glass cap.

3.5 AMBIENT MM5 SAMPLING TRAIN

The ambient MM5 sampling train was located on the roof of the plant beside the sampling train scaffolding. The train was set up according to the description presented in Radian's test plan. Since three runs were to be composited into a single sample, the train was not disassembled between runs.

On the day of the audit, the XAD resin organic trap was not continuously cooled between runs. Since the trap was located out-of-doors and was subject to relatively cool ambient temperatures, continuous cooling of the resin was probably not crucial. Nevertheless, the adsorption of organic gases into XAD is somewhat sensitive to temperature, and continuous cooling between runs should be incorporated into future tests where possible. (EPA's Level 2 guidelines note that a 10 °C change in the sorbent module temperature will result in a factor-of-two change in the volumetric capacity of the resin for a particular compound.[7])

The ambient train was located beside the stack near the ambient air intake damper. Although the train would ordinarily be located near the combustion air intake, the ambient air intake damper site was approved by EPA prior to the test. This site allowed the test team to determine whether any chlorinated organic compounds measured in the stack by the MM5 sampling train were contributed by gases sucked in through the ambient air damper.

It is recommended that the ambient XAD resin trap be cooled on a continuous basis between runs (as well as during runs) whenever the train is located in a hot or variable-temperature environment.

3.6 HCl SAMPLING TRAIN

The HCl train was operated in an acceptable manner, except that a break was discovered in the probe at the end of the test. Often these types of problems occur no matter how much care is exercised, although just as often the problem can be avoided through more careful handling of equipment.

It is recommended that Radian take precautions as necessary to avoid any future breakage of equipment, as occurred with the HCl sampling probe on the day of the audit.

3.7 CONTINUOUS EMISSION MONITORS

The continuous emission monitoring system consisted of a coarse filter, sampling probe, heated sampling line, moisture removal system, monitoring units, strip charts, and an automated data acquisition system. (Gases sent to the hydrocarbon monitor bypassed the moisture removal system.) A separate bag sample was periodically taken at a point above the ambient air intake damper to determine the extent of dilution at the damper. Strip charts were carefully marked and all calibration data were recorded. Three-point calibrations were performed at the beginning of the test program, and two-point calibrations were performed at the beginning and end of each test run. Calibration and quality control gases were introduced at the end of the sample line near the moisture removal system. Thus, the entire sampling interface was not tested by these gases. (Radian indicated that the entire interface would be tested during future tests.)

Separate gas cylinders were used for calibration and quality control. The quality control gases were used before each run, immediately following the span check. The monitor meter should be allowed to return to zero before the monitor is challenged with the quality control gas; however, this was not done. (By allowing the monitor to return to zero, the quality control check becomes truly independent of the span check.) The quality control gases were calibrated by the vendor against NBS standards, and none of the cylinders were allowed to fall below 200 lb pressure. The cylinders are returned to the vendor for reverification at the end of each test series.

Data were collected by the data acquisition system at 5-minute intervals, and corrections for drift were made at the end of the test run. This procedure worked nicely, except that the data acquisition system did not incorporate a time constant to average out noise peaks in the monitor signal. (However, since readings were taken so frequently, positive peaks were probably balanced by negative peaks such that the net effect was little or no bias.) Monitor drift was not bad, except for the NO_x monitor during significant temperature variations inside the continuous monitor trailer. (Radian indicated that this problem would be solved once their new trailer is outfitted and put in service.) Finally, strip charts were offset 5 percent rather than the recommended 10 percent.[8]

We have the following recommendations for the continuous emission monitoring system: (1) calibration and quality control gases for the continuous emission monitors should test the entire sampling interface; (2) continuous monitor meter readings should be allowed to return to zero before challenging the meter with a quality control gas; (3) if possible, the continuous monitor data acquisition system should incorporate a time constant to average out peaks in the monitor signal; (4) temperature variations within the continuous monitor trailer should be minimized; and (5) continuous monitor strip charts should be offset 10 percent.

3.8 PROCESS SAMPLES

The process sample collection activities involved the collection of representative samples of waste feed, No. 2 fuel oil, and incinerator bottom ash. The waste feed samples consisted of paint sludge, wood and plastic cutoffs, crate parts, paper, and cardboard. Representative samples of waste feed were very difficult to obtain due to the bulkiness of some materials and the thick consistency of the paint sludge. The test team worked hard to homogenize the waste sludges; however, their attempts were largely unsuccessful.

3.9 SAMPLE HANDLING, TRANSPORTATION, AND STORAGE

Radian reported that during earlier dioxin testing, several bottles broke during shipment. This problem is now avoided by sealing the bottles inside two insulated plastic bags separated by packing material. Under these conditions future breakage seems unlikely.

While the Radian test was in progress it was observed that the liquid level was not marked on the sample collection bottles. Instead, bottle weights were recorded before and after the bottles were filled. Radian's procedure is certainly more accurate than the procedure of marking liquid levels directly on the bottle. However, their procedure has a problem in that there is no quick and convenient way to determine whether any liquid loss has occurred. (According to Radian, the bottle weights are not checked back at the laboratory unless the physical appearance of the bottle indicates that some leakage may have occurred.)

It is recommended that Radian mark the liquid level on all sample collection bottles.

3.10 SOIL SAMPLING

The soil sampling activities appeared generally to follow the procedures specified in the Test Plan. (More details concerning these procedures are presented in the appendix to this report.) However, there are three aspects of these activities that could be improved. First, site selection was a problem at this test site due to the small amount of open land available in the vicinity of the incinerator. The site selected was probably the most logical one under the circumstances. However, if one objective of the sampling of soils is to search for dioxins deposited by stack emissions, the location selected may have been too close to the stack to permit effective downwash to occur.

Another concern about the soil sampling program is the proximity of the soil samples to one another. Ideally, the samples should cover a wide area of the grounds surrounding the plant. However, at the incinerator test site the 10 samples were taken within a rectangle of approximately 3 by 9 feet. (This area was selected because of the scarcity of suitable land for sampling near the plant.) The consequence of taking closely spaced samples is to provide data that represent only a very small segment of the land surrounding the plant.

An additional concern is the manner in which the soil samples were composited. During the audit there seemed to be some confusion about whether the compositing should be performed by hand or by using a tool such as a garden trowel. Use of a hexane-rinsed garden trowel is preferable.

A final comment concerns the cleaning of surface debris (e.g., leaves and dead grass) from the soil sampling area before sample collection is performed. Radian did not implement this procedure, although little significant debris was present.

RTI has the following soil sampling recommendations: (1) in the future Radian should conduct soil sampling over a wide area where potential dioxin contamination is most likely; (2) soil samples should be composited using an appropriate tool, such as a hexane-rinsed garden trowel; and (3) all debris (e.g., leaves and dead grass) should be cleaned from the ground before soil sampling is begun.

4.0 CONCLUSIONS

Overall, RTI was impressed with the Radian test team and the quality of their work. Although on the day of the audit testing was interrupted several times due to process disruptions, these problems were beyond the control of the test team. RTI is satisfied that the data generated by the test program will be of sufficient quality to achieve the objectives of the study, provided that: (1) the analytical procedures, which will be evaluated under a separate audit, are performed correctly; and (2) the sampling procedures continue to be performed with the same level of care exhibited during the Site ISW-A incinerator tests. However, the quality of data could be further improved if the recommendations contained in this report are implemented. These recommendations are summarized in Table 2.

5.0 REFERENCES

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2. M. A. Palazzolo, R. F. Jongleux, and L. E. Keller. "National Dioxin Study Tier 4, Combustion Sources, Quality Assurance Project Plan." DCN No. 84-231-056-12-03. Research Triangle Park, North Carolina. September 21, 1984.

3. Radian Corporation. "Draft Report, National Dioxin Study Tier 4, Combustion Sources, Sampling Procedures." DCN No. 84-240-016-51-09. Research Triangle Park, North Carolina. October 17, 1984.

4. U.S. Environmental Protection Agency. "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans." QAMS-005/80. December 29, 1980.

5. Richard V. Crume, Research Triangle Institute. Letter to Mr. Bill Kuykendal, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency. October 23, 1984.

6. Richard V. Crume, Research Triangle Institute. Letter to Mr. Bill Kuykendal, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency. November 8, 1984.

7. U.S. Environmental Protection Agency. "EPA/IERL-RTP Procedures for Level 2 Sampling and Analysis of Organic Materials." EPA-600/7-79-033. February 1979.

8. U.S. Environmental Protection Agency. "Handbook: Continuous Air Pollution Source Monitoring Systems." EPA-625/6-79-005. June 1979.

6.0 APPENDIX

6.1 AUDIT CHECKLISTS

Detailed information concerning the Site ISW-A industrial incinerator audit is presented in the following audit checklists.

METHOD 5 SAMPLING CHECK LIST*

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Calibration of dry gas meter against standard	X		Footnote A
Dry gas meter reading within ± 5% of calibration orifice			Footnote B
Calibration of stack temperature sensor against reference thermometer	X		
Nozzle calibrated to nearest 0.025 mm (0.001 in); size properly selected	X		
Trains correctly set-up and leak-checked (<4% or 0.00057 m^3/min, 0.02 ft^3/min, whichever is less); see attached figure.	X		
Train components are clean and free of breaks, cracks, and leaks; probe liner is clean and leak free at 380 mm (15 in) Hg	X		
Pitot tube lines are free of plugs or leaks	X		
Probe heating system is operating	X		
Pitot tube and temperature sensor are properly attached to probe	X		
Pitot tubes, meter box, and temperature sensors are recently calibrated	X		Footnote C

*This check list was used to evaluate the Modified Method 5 sampling train.

METHOD 5 SAMPLING CHECK LIST (Continued)

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Nozzle and pitot tube are parallel to stack wall	X		
Filter holder temperature remains 120 ±14°C (248 ± 25°F) throughout test	X		
Sample gas temperature at last impinger remains <20°C (68°F) throughout test	X		
Isokinetic sampling within ±10%; checked every five minutes	X		
Sample site selection is appropriate distance downstream from flow disturbance	X		Footnote D
Filters are free of irregularities, properly installed, and properly labeled	X		
Operators have access to test protocol and methods; data sheets available; equipment in good repair	X		Footnote E
All data recorded; calculations checked; at least one decimal point beyond that of acquired data is retained	X		Footnote F
All impingers remain cooled in an ice bath at all times	X		
Full stack traversing being conducted	X		Footnote G

METHOD 5 SAMPLING CHECK LIST (Continued)

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Sample recovery:			
Method prevents contamination	X		
Graduated cylinder subdivisions are < 2 ml	X		
Cap placed over nozzle tip	X		
All openings capped during train disassembly	X		Footnote H
Clean-up area clean and protected from wind	X		Footnote I
No particulate spilled	X		
No visible particles remain inside probe	X		
Sample containers labeled, sealed tight, liquid level marked		X	Footnote J

MODIFIED METHOD 5 ADDENDUM

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Cartridge (with XAD) mounted vertically atop the first impinger		X	Footnote K
Cyclone, flask, and filter holder maintained (thermostatically) at a temperature of 120°C ± 14°C (248°F ± 25°F)	X		
Sample gas and XAD cooled to ≤20°C	X		Footnote L
XAD resin never subject to temperature greater than 100°C during preparation, transfer, and storage	X		
Greaseless types of joints and seals used in train	X		
XAD storage under refrigeration in either air tight glass containers or under ethanol or methanol	X		
Storage time of XAD after cleaning ≤ 2 months	X		
Samples of XAD batch analyzed just prior to use in the field	X		
Sample recovery			
XAD-2 handling procedure properly implemented	X		
Same solvents used for resin extraction and cleaning sequence	X		

FOOTNOTES--MODIFIED METHOD 5 SAMPLING CHECKLIST

A The dry gas meter was calibrated against a wet test meter standard several weeks prior to the audit.

B Radian will check the calibration of the dry gas meter using a calibrated orifice supplied by RTI. The calibration data will be returned to RTI for analysis. (Radian was not provided with the orifice calibration factor.)

C All calibrations were performed about 4 weeks prior to the audit.

D The sampling location was about 13 feet from the ambient air intake damper.

E The sampling equipment was rather old, but appeared to be well maintained.

F Audit data were used to examine the accuracy of Radian's computerized calculations.

G Twenty-four point traverses were performed.

H Openings capped using hexane-rinsed aluminum foil.

I The cleanup area was located inside a closed trailer.

J Liquid levels were not marked on bottles. Instead, bottle weights were taken both before and after the bottles were filled, and this information was recorded on the bottle labels.

K The XAD cartridge was vertical, but the condenser was mounted in a horizontal position.

L Cooling was achieved using water from the impinger ice bath.

METHOD 5 SAMPLING CHECK LIST*

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Calibration of dry gas meter against standard			Footnote A
Dry gas meter reading within ± 5% of calibration orifice			NA
Calibration of stack temperature sensor against reference thermometer			NA
Nozzle calibrated to nearest 0.025 mm (0.001 in); size properly selected			NA
Trains correctly set-up and leak-checked (<4% or 0.00057 m^3/min, 0.02 ft^3/min, whichever is less); see attached figure.			NA
Train components are clean and free of breaks, cracks, and leaks; probe liner is clean and leak free at 380 mm (15 in) Hg			NA
Pitot tube lines are free of plugs or leaks			NA
Probe heating system is operating			NA
Pitot tube and temperature sensor are properly attached to probe		X	
Pitot tubes, meter box, and temperature sensors are recently calibrated			NA

*This check list was used to evaluate the Blank Modified Method 5 train.

NA = Not Applicable

METHOD 5 SAMPLING CHECK LIST (Continued)

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Nozzle and pitot tube are parallel to stack wall			NA
Filter holder temperature remains 120 ±14°C (248 ± 25°F) throughout test			NA
Sample gas temperature at last impinger remains <20°C (68°F) throughout test			NA
Isokinetic sampling within ±10%; checked every five minutes			NA
Sample site selection is appropriate distance downstream from flow disturbance			Footnote B
Filters are free of irregularities, properly installed, and properly labeled	X		
Operators have access to test protocol and methods; data sheets available; equipment in good repair	X		
All data recorded; calculations checked; at least one decimal point beyond that of acquired data is retained			NA
All impingers remain cooled in an ice bath at all times		X	
Full stack traversing being conducted			NA

METHOD 5 SAMPLING CHECK LIST (Continued)

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Sample recovery:			
Method prevents contamination			NA
Graduated cylinder subdivisions are < 2 ml			NA
Cap placed over nozzle tip		X	Footnote C
All openings capped during train disassembly	X		
Clean-up area clean and protected from wind	X		
No particulate spilled			NA
No visible particles remain inside probe			NA
Sample containers labeled, sealed tight, liquid level marked	X		

MODIFIED METHOD 5 ADDENDUM

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Cartridge (with XAD) mounted vertically atop the first impinger		X	Footnote D
Cyclone, flask, and filter holder maintained (thermostatically) at a temperature of 120°C ± 14°C (248°F ± 25°F)			NA
Sample gas and XAD cooled to ≤20°C			NA
XAD resin never subject to temperature greater than 100°C during preparation, transfer , and storage	X		
Greaseless types of joints and seals used in train	X		
XAD storage under refrigeration in either air tight glass containers or under ethanol or methanol	X		
Storage time of XAD after cleaning ≤ 2 months	X		
Samples of XAD batch analyzed just prior to use in the field	X		
Sample recovery	X		
XAD-2 handling procedure properly implemented	X		
Same solvents used for resin extraction and cleaning sequence	X		

FOOTNOTES--BLANK MODIFIED METHOD 5 SAMPLING CHECKLIST

A The blank train did not incorporate either a meter box or a probe nozzle. The train consisted only of the probe, filter, condenser, resin, and impingers. The impingers were left empty, and the impinger box was not filled with ice water.

B The train was located on the roof of the plant, at the base of the stack scaffolding. The distance from the train to the top of the two incinerator stacks was about 30 feet.

C Both ends of the train were left unsealed while testing was in progress.

D The XAD cartridge was vertical, but the condenser was mounted in a horizontal position.

METHOD 5 SAMPLING CHECK LIST*

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Calibration of dry gas meter against standard	X		Footnote A
Dry gas meter reading within ± 5% of calibration orifice			Footnote B
Calibration of stack temperature sensor against reference thermometer			NA
Nozzle calibrated to nearest 0.025 mm (0.001 in); size properly selected			NA
Trains correctly set-up and leak-checked (<4% or 0.00057 m^3/min, 0.02 ft^3/min, whichever is less); see attached figure.	X		
Train components are clean and free of breaks, cracks, and leaks; probe liner is clean and leak free at 380 mm (15 in) Hg	X		
Pitot tube lines are free of plugs or leaks			NA
Probe heating system is operating			NA
Pitot tube and temperature sensor are properly attached to probe			NA
Pitot tubes, meter box, and temperature sensors are recently calibrated			NA

*This check list was used to evaluate the Ambient Modified Method 5 Train.
NA = Not Applicable

METHOD 5 SAMPLING CHECK LIST (Continued)

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Nozzle and pitot tube are parallel to stack wall			NA
Filter holder temperature remains 120 ±14°C (248 ± 25°F) throughout test			NA
Sample gas temperature at last impinger remains <20°C (68°F) throughout test			NA
Isokinetic sampling within ±10%; checked every five minutes			NA
Sample site selection is appropriate distance downstream from flow disturbance			Footnote C
Filters are free of irregularities, properly installed, and properly labeled			NA
Operators have access to test protocol and methods; data sheets available; equipment in good repair	X		Footnote D
All data recorded; calculations checked; at least one decimal point beyond that of acquired data is retained	X		Footnote E
All impingers remain cooled in an ice bath at all times			NA
Full stack traversing being conducted			NA

METHOD 5 SAMPLING CHECK LIST (Continued)

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Sample recovery:			
Method prevents contamination	X		
Graduated cylinder subdivisions are < 2 ml	X		
Cap placed over nozzle tip	X		
All openings capped during train disassembly	X		Footnote F
Clean-up area clean and protected from wind	X		Footnote G
No particulate spilled			NA
No visible particles remain inside probe			NA
Sample containers labeled, sealed tight, liquid level marked		X	Footnote H

MODIFIED METHOD 5 ADDENDUM

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Cartridge (with XAD) mounted vertically atop the first impinger	X		
Cyclone, flask, and filter holder maintained (thermostatically) at a temperature of 120°C ± 14°C (248°F ± 25°F)			NA
Sample gas and XAD cooled to ≤20°C			Footnote I
XAD resin never subject to temperature greater than 100°C during preparation, transfer , and storage	X		
Greaseless types of joints and seals used in train	X		
XAD storage under refrigeration in either air tight glass containers or under ethanol or methanol	X		
Storage time of XAD after cleaning ≤ 2 months	X		
Samples of XAD batch analyzed just prior to use in the field	X		
Sample recovery			
XAD-2 handling procedure properly implemented	X		
Same solvents used for resin extraction and cleaning sequence	X		

FOOTNOTES--AMBIENT MODIFIED METHOD 5 SAMPLING CHECKLIST

A The dry gas meter was calibrated against a wet test meter standard several weeks prior to the audit.

B Radian will check the calibration of the dry gas meter using a calibrated orifice supplied by RTI. The calibration data will be returned to RTI for analysis. (Radian was not provided with the orifice calibration factor.)

C The train was located on the roof of the plant at the base of the stack scaffolding. The distance from the train to the top of the two incinerator stacks was about 30 feet.

D The sampling equipment was rather old, but appeared to be well maintained.

E Audit data were used to examine the accuracy of Radian's computerized calculations.

F Openings capped using hexane-rinsed aluminum foil.

G The cleanup area was located inside a closed trailer.

H Liquid levels were not marked on bottles. Instead, bottle weights were taken both before and after the bottles were filled, and this information was recorded on the bottle labels.

I Since the resin is cooled with ambient air between tests, a temperature of less than 20 °C may be difficult to maintain on a warm day.

METHOD 5 SAMPLING CHECK LIST*

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Calibration of dry gas meter against standard	X		Footnote A
Dry gas meter reading within ± 5% of calibration orifice			Footnote B
Calibration of stack temperature sensor against reference thermometer	X		
Nozzle calibrated to nearest 0.025 mm (0.001 in); size properly selected	X		
Trains correctly set-up and leak-checked (<4% or 0.00057 m^3/min, 0.02 ft^3/min, whichever is less); see attached figure.	X		
Train components are clean and free of breaks, cracks, and leaks; probe liner is clean and leak free at 380 mm (15 in) Hg		X	Footnote C
Pitot tube lines are free of plugs or leaks	X		
Probe heating system is operating	X		
Pitot tube and temperature sensor are properly attached to probe	X		
Pitot tubes, meter box, and temperature sensors are recently calibrated	X		Footnote D

* This check list was used to evaluate the HCl sampling train.

METHOD 5 SAMPLING CHECK LIST (Continued)

REQUIREMENT OR PROCEDURE	ACHIEVED? YES	ACHIEVED? NO	COMMENTS
Nozzle and pitot tube are parallel to stack wall	X		
Filter holder temperature remains 120 ±14°C (248 ± 25°F) throughout test	X		
Sample gas temperature at last impinger remains <20°C (68°F) throughout test	X		
Isokinetic sampling within ±10%; checked every five minutes	X		
Sample site selection is appropriate distance downstream from flow disturbance	X		Footnote E
Filters are free of irregularities, properly installed, and properly labeled	X		
Operators have access to test protocol and methods; data sheets available; equipment in good repair	X		Footnote F
All data recorded; calculations checked; at least one decimal point beyond that of acquired data is retained	X		Footnote G
All impingers remain cooled in an ice bath at all times	X		
Full stack traversing being conducted		X	Footnote H

METHOD 5 SAMPLING CHECK LIST (Continued)

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Sample recovery:			
Method prevents contamination	X		
Graduated cylinder subdivisions are < 2 ml	X		
Cap placed over nozzle tip	X		
All openings capped during train disassembly	X		Footnote I
Clean-up area clean and protected from wind	X		Footnote J
No particulate spilled	X		
No visible particles remain inside probe	X		
Sample containers labeled, sealed tight, liquid level marked			Footnote K

FOOTNOTES--HCl SAMPLING CHECKLIST

A The dry gas meter was calibrated against a wet test meter standard several weeks prior to the audit.

B Radian will check the calibration of the dry gas meter using a calibrated orifice supplied by RTI. The calibration data will be returned to RTI for analysis. (Radian was not provided with the orifice calibration factor.)

C At the end of the run on the day that the audit took place, the test team discovered that the HCl sampling probe had cracked. Since the time at which the crack occurred could not be determined, the run was invalidated.

D All calibrations were performed about 4 weeks prior to the audit.

E The sampling location was about 13 feet from the ambient air intake damper.

F The sampling equipment was rather old, but appeared to be well maintained.

G Audit data were used to examine the accuracy of Radian's computerized calculations.

H Sampling was performed at the point of average velocity in the stack, as specified in the Radian test plan.

I Openings capped using hexane-rinsed aluminum foil.

J The cleanup area was located inside a closed trailer.

K Liquid levels were not marked on bottles. Instead, bottle weights were taken both before and after the bottles were filled, and this information was recorded on the bottle labels.

CONTINUOUS EMISSION MONITOR CHECK LIST

CEM 1/2

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
I. Gases Monitored (Instrument to be Used):			
CO_2 (Anarad 412)	X		
CO (Anarad 412)	X		
NO_2 (Teco 10)	X		
NO (Teco 10)	X		
SO_2 ( )			
O_2 (Beckman 755)	X		
THC (Beckman 402)	X		
Opacity ( )			
Other ( )			
II. Calibration: Performed at least every 24 hours by experienced personnel following manufacturer's instructions	X		Footnote A
Cal gases verified within last 6 months; tank pressure above 100 psi	X		Footnote B
Calibration checks entire sampling interface	X		Footnote C
Zero and span values checked at the beginning and end of each run	X		
III. Records: Data continuously recorded on strip-charts or computer, and periodically averaged	X		Footnote D

CONTINUOUS EMISSION MONITOR CHECK LIST (continued)

REQUIREMENT OR PROCEDURE	ACHIEVED? YES	ACHIEVED? NO	COMMENTS
III. Con't			
Strip-chart zero offset 10% at recorder; charts clearly identified	X		Footnote E
All calibrations, maintenance, and problems recorded in log book	X		
Unusual readings are immediately brought to the attention of the team leader	X		
IV. General:			
Instrument/stack interface appears adequate:			
In-stack sample probe	X		
Coarse filter	X		
Heat-traced sample line	X		
Sampling pump	X		
Moisture removal	X		
Fine filter	X		
Manifold design	X		
Drift appears normal	X		Footnote F
Representative sampling site selected	X		
Maintenance procedure followed	X		

FOOTNOTES--CONTINUOUS EMISSION MONITOR SAMPLING CHECKLIST

A A three-point calibration was performed at the beginning of the test program. Two-point calibrations are performed at the beginning and end of each test run.

B Quality control gas cylinders are certified by the vendor against an NBS standard. All gases are periodically returned to the vendor for recertification. Pressures are not allowed to go below 200 psi.

C The calibration gases check the entire interface except for the sample line leading from the stack sampling probe.

D A data acquisition system records data at 5-minute intervals. This system does not average readings over time. Instead, it takes an instantaneous reading without regard for whether that reading is at the top, center, or bottom of a noise fluctuation.

E The offset is 5 percent.

F All data are corrected for drift at the end of each run. The NO_x monitor, which tends to be more temperature-sensitive than the other instruments, exhibited a greater drift than the other instruments. This drift, however, was not excessive.

PROCESS SAMPLE CHECK LIST

PS 1/2

REQUIREMENT OR PROCEDURE	ACHIEVED? YES	ACHIEVED? NO	COMMENTS
Type of sample collected:			
ASH: Incinerator bottom ash	X		
FUEL: No. 2 Fuel oil	X		
FEED: Waste Feed	X		Footnote A
QUENCH WATER:			
OTHER:			
Collection point: Incinerator			
Sample containers are carefully sealed; liquid levels marked		X	Footnote B
Samples are representative in terms of: Process variations with time The total quantity of material under investigation	X		Footnote C
Samples are composited and/or homogenized, where appropriate	X		
A sufficient quantity of sample is collected	X		
Amber glassware is used for all liquid sample collection	X		
All glassware sealed with aluminum foil or Teflon-lined cap	X		

PROCESS SAMPLE CHECK LIST

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
All sample containers are solvent cleaned prior to reuse; solvent will not interfere with analytical method	X		
Sample containers are clearly labeled	X		
All samples are properly preserved, if not extracted within established time limit	X		

FOOTNOTES--PROCESS SAMPLE CHECKLIST

A The waste feed consisted of paint sludge, wood and plastic cutoffs, crate parts, paper, and cardboard.

B Liquid levels were not marked on bottles. Instead, bottle weights were taken both before and after the bottles were filled, and this information was recorded on the bottle labels.

C Representative waste feed samples were difficult to obtain due to the bulkiness of some materials and the thick consistency of the paint sludge. The test crew did the best they could under the circumstances.

SAMPLE HANDLING, TRANSPORTATION, AND STORAGE CHECK-LIST

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
All potentially hazardous samples are handled according to established safety procedures	X		
All sample containers are tightly sealed and carefully packaged for shipment. Plastic or aluminum wraps are used where appropriate	X		Footnote A
Samples are not stored or packaged with potential contaminants (In some cases, audit samples may be a source of contamination for other samples)	X		
Precautions should be taken in the field to avoid contamination (e.g., work areas should be clean; airborne dust should be avoided; workers should wear clean, disposal gloves)	X		
A sample custody log and a record of all field activities should be maintained; custody sheets should accompany samples during shipments	X		
Samples should be carefully labeled	X		
The duration of sample transportation and storage should not exceed the maximum recommended holding time for the sample	X		
Samples should be stored at appropriate temperatures	X		
Changes in ambient temperature and pressure during shipment (e.g., by air) should be considered	X		

FOOTNOTES--SAMPLE HANDLING, TRANSPORTATION, AND STORAGE CHECKLIST

A During a preceding field test (the second test site of this study), several bottles broke during shipment. To avoid this problem in future tests, bottles are now sealed inside two insulated plastic bags, separated by packing material. Under these circumstances future breakage seems unlikely.

SOIL SAMPLING CHECK LIST

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
The sampling technique selected is appropriate given the QA objectives of the study	X		
The sample location, sample depth, and number of samples collected are appropriate for the study	X		Footnote A
Sample segmenting or homogenization procedures used where necessary			Footnote B
Any deviations from the sampling QA plan are documented and justified	X		
Debris properly cleared from sampling location			Footnote C
All equipment thoroughly cleaned before taken to the field; any solvent rinse used will not interfere with the sample analysis	X		
All cleaned scoops, spoons, coring tubes, augers, etc. should be wrapped in aluminum foil during storage and transfer	X		
Separate onsite area designated for cleaning and decontamination of sampling equipment, if required	X		
Proper container selection; wide-mouth amber glass jars preferred	X		

SOIL SAMPLING CHECK LIST (Continued)

REQUIREMENT OR PROCEDURE	ACHIEVED?		COMMENTS
	YES	NO	
Samples stored under appropriate conditions (e.g., darkness or refrigeration)	X		
All jars have screw-type lids lined with a material that will not cause interference with the analytical method or react with any compounds in the soil	X		
Plastic bag secured around sample containers to avoid contamination	X		
Appropriate labeling and chain of custody procedures followed for all containers	X		
All pertinent information recorded in log book	X		Footnote D

FOOTNOTES--SOIL SAMPLING CHECKLIST

A Five samples were collected at 2-foot intervals in each of two rows. The rows were parallel and were spaced about 3 feet apart, as illustrated below.

X^1 X^3 X^5 X^7 X^9

X^2 X^4 X^6 X^8 X^{10}

(The samples are numbered according to the order in which they were collected.)

Each sample was collected by: (1) forcing the bulb planter about 3 inches into the ground; (2) emptying the contents into a bucket; (3) forcing the planter into the ground a second time at an adjacent location; and (4) again emptying the contents into the bucket. Once two samples (i.e., four bulb planters) were collected, the bucket was returned to the laboratory area where the contents of the bucket was mixed, and a portion transferred to an amber glass bottle. Transfers were made by a member of the test crew wearing a plastic glove. The remainder of the bucket contents was discarded. The above procedure was repeated five times so that a total of ten samples were collected.

The sampling site was located on a small plot of land approximately 100 feet from the base of the incinerator stack. Since the sampling site was located near a fire hydrant, it is unlikely that dumping or grading ever took place in that area. (It is possible that the rinsing of vehicles or other equipment took place in the vicinity of the fire hydrant. However, there was no evidence that this actually occurred.)

B The contents of buckets were broken apart, but were not thoroughly mixed, prior to the filling of bottles.

C Surface debris, consisting of a thin layer of dead grass, was not removed prior to insertion of the bulb planter.

D A good drawing of the sampling area was made. Distances were estimated, but were not accurately measured using a tape measure.

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16. ABSTRACT

This report summarizes the results of a dioxin/furan emissions test of an industrial solid waste incinerator combusting various wastes from the manufacture of wooden windows and doors. The test was the second in a series of several dioxin/furan emissions tests conducted under Tier 4 of the National Dioxin Study. The primary objective of Tier 4 is to determine if various combustion sources are sources of dioxin and/or furan emissions. If any of the combustion sources are found to emit dioxin or furan, the secondary objective of Tier 4 is to quantify these emissions.

Industrial solid waste incinerators are one of eight combustion source categories tested in the Tier 4 program. The host solid waste incinerator, designated throughout this report as incinerator ISW-A, was selected for testing after an initial information screening and a one-day pretest survey visit.

Data presented in the report include dioxin (tetra through octa homologue + 2378 TCDD) and furan (tetra through octa homologue + 2378 TCDD) results for both stack samples and ash samples. In addition, process data collected during sampling are also presented.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Emissions Combustion Sources Dioxin Furans 2,3,7,8 Tetrachlorodibenzo-p-dioxin Industrial Solid Waste Incinerator Incineration	Air Pollution Emissions Data	

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